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THE NEW STEEL PLANT being built by the Lackawanna Iron & Steel Co., of Scranton and Lebanon, Pa., at Buffalo, N. Y., will occupy 1,400 acres of land along the lake front, near Stony Point. The plant fronts on the new harbor formed by the government breakwater now nearly completed, and it connects with 26 railways entering Buffalo. A canal, 200 ft. wide, is to be excavated parallel to the lake front and connecting with the harbor and large enough to take the biggest ore-boats coming from the Lake Superior regions, and the Wellman-Seaver Engineering Co. will put in an unloading and handling plant. On one side of the canal will be a battery of Otto-Hoffman by-product ovens, and the general mill buildings will be parallel to this canal. The works will be in operation next year, and the capacity of the plant will be 800,000 to 1,000,000 tons of steel per annum. A certain proportion of the pig-iron will be made at Lebanon, Pa., and the special ore-roasting plant will be moved from Scranton to Lebanon. The two steel plants and blast furnaces at Scranton will gradually be dismantled.

THE ALLIS-CHALMERS CO. is said to be the name selected for the company which is reported as about to be organized to take over the shops of the E. P. Allis Co. at Milwaukee, the Gates Iron Works and Fraser & Chalmers at Chicago, and the Dickson Co. works at Scranton, Pa. The new company is to have a capitalization of $12,500,000 preferred stock and $20,000,000 common stock.

THE LEYLAND LINE OF STEAMERS has been purchased by J. Pierpont Morgan & Co., and it is reported that it will be consolidated with the Atlantic Transport Line. The Leyland Line owns 65 steamships, 12 of them large passenger carriers. It operates lines between New York and Liverpool; Boston and Liverpool; Boston and London; Portland, Me., to Antwerp; Quebec to London; New Orleans to London and Liverpool; Liverpool to Barbadoes, St. Thomas and Trinidad, and Liverpool to Portugal, Egypt and Constantinople. The Atlantic Transport Line owns 17 steamships and is building 6 or 8 more; it is an English company, but 89% of the stock is owned in the United States.

THE GEORGIAN BAY SHIP CANAL, says its promoters, can be built for $65,000,000, and if the government will guarantee 2¼ or 3% on this capital or co-operate in some other way with the company, the canal will be built. All the surveys have been completed for a 20-ft. canal. The promoters claim that with this canal built, grain could be carried from lake ports to the seaports for 3 cts. a bushel.

A BLACK SEA-CASPIAN CANAL is again under discussion, this time by the Russian Hydrotechnic Congress. As the existing railways are said to be unable to handle the traffic between the Russian coal regions and the petroleum and cotton producing sections of Central Asia, the canal is projected to connect Astrakan, at the month of the Volga, with Taganrog, on the Sea of Azov. This is practically the old Don-Volga route. The projected canal would have a depth of 22 ft., and is estimated to cost $22,225,000.

THE ANNUAL REPORT OF THE GENERAL ELECTRIC Co. announces a profit of $6,244,439 on the business of the last year; of this profit $1,968,289 was paid in dividends and the remainder placed to surplus account. The sales department reports total orders received in the year ending Jan. 31, 1901, amounting to $37,969,541; the largest total for any preceding year was $17,431,327, in 1899. In the last year over 150,000 separate supply orders were received averaging over $60 each, and 12,000,000 incandescent lamps were ordered. Orders were also received for over 330,000 HP. of alternating and direct-current motors; and more than 600,000 HP. of electric motors and transformers for various purposes. Among the contracts closed was one for the equipment of a long-distance transmission plant to operate mining machinery at the Kolar gold fields, in Mysore, India; this plant, a pole-line nearly 100 miles long, for supplying 4,000 HP. to the motors. This enormous increase in business has required the expenditure of about $1,200,000 in extending the plant at Schenectady; these factories now cover 2,500,000 sq. ft. of floor space and employ over 12,000 people. The report itself is a model document, in the information given to the stockholders as to the business and financial status of the company.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred near Dayton, O., on the Cincinnati, Hamilton & Dayton R. R., on April 25. An express train running at about 70 miles per hour was derailed on a sharp curve by the breaking of one of the locomotive truck wheels. The engineer and fireman were killed and ten persons were seriously hurt.

AN EXPLOSION OF GAS occurred on April 29 in the mine of the McAlester Coal Co., at Alderson, Indian Territory, by which five men were killed and seven injured.

A FOUR-TRACK SCHERZER ROLLING-LIFT BRIDGE is to be constructed across the Pequannock River at Bridgeport, Conn., after designs and plans prepared by the Scherzer Rolling Lift Bridge Co., of Chicago, Ill. The new bridge is to replace the existing double-track swing bridge, which will be discarded and removed in the process of four-tracking the main lines of the New York, New Haven & Hartford R. R. Co. at this point. The new bridge will be a deck structure, and will consist of two parallel, double-track, movable spans, which may be operated together or singly, as desired. The motive power will be electricity, and the bridge will, it is stated, be opened or closed in less than 30 seconds. The bridge will be designed to carry the heaviest loads, in accordance with the specifications of the New York, New Haven & Hartford R. R. Co. of 1901.

ANOTHER DEATH IN THE CASCADE TUNNEL is reported. On April 19, 11 section hands were overcome by smoke and gas in the tunnel, and one of them died in consequence. An extra freight train entered the tunnel soon after the gang started in and a track walker found the whole party prostrated from gas an hour later. The tunnel, which is nearly three miles long, was described by Mr. John F. Stevens, Chief Engineer of the Great Northern R. R., in our issue of Jan. 10. A previous death from gas in the tunnel occurred on March 25.

THE FALL OF AN IRON TANK for a sprinkler fire-protection service occurred April 21 at the Galbreath Building, 215 Madison St., Chicago. The building is six stories high, and the tank broke through every floor, but as the accident occurred on Sunday and the building was almost empty, few people were hurt and nobody was killed. The building was not new, but the sprinkler system had only just been put in. The 60,000-gallon tank was carried on steel trusses resting on the walls of the building, and it remains to be seen whether there was any direct failure of the trusses or the walls. The Building Department officials state that the very high wind caused vibration, which led to the 12-in. brick walls giving way under the structure. The trusses and tanks were designed by different parties, and the designers of the trusses had nothing to do with the material used or with the erection, so that responsibility is considerably divided.

A DAM AND AN ARCHED MASONRY RAILWAY bridge were wrecked at Middlefield, Mass., on April 21. The bridge was located on the main line of the Boston & Albany R. R., between Springfield and Pittsfield, Mass. The wrecks were caused by floods which, in addition, caused widespread minor damages in the vicinity named. The dam is described by the Springfield "Republican" as of earth reinforced along the center by a wall of masonry 8 ft. thick at the base and 4 ft. at the top, the wall being 15 to 30 ft. high. Abutting on this wall at one end was a wasteway, controlled by "two series of gates, one above the other," over which there was a bridge. The gates were partly open, when it was discovered that the water was overflowing the adjoining roadway. Access to the gates being impossible, warning was given below that the dam was likely to fail. The dam gave way at the center, but the break was somewhat slow, so the flood was not so bad as it might have been otherwise. Four highway bridges along the stream, three of iron, were carried away and the road damaged before the flood struck the masonry arch, three miles below, at the Middlefield railway station. The exact size of the arch is not given, but it appears to have had a span of 35 or 40 ft. The dam was built in 1874, "approved by the county commissioners, and was afterwards further reinforced by a stone wall," described above. A dam on the same site was erected about 1792 and enlarged in 1800. On July 10, 1874, the original, or some later, structure on that site was washed out by a flood, following the failure of two dams above it. The dam appears to have furnished power, latterly, to quartz mills owned by Mr. G. W. I. Landau, of Paterson, N. J.

THE FAILURE OF A WATER TANK OR STAND-PIPE at Hillsboro, N. D., is reported as having occurred on April 20. The cause is given as "defective foundation and inadequate strength of material." The structure had a capacity of about 75,000 gallons and a height of 180 ft. Three barns and the corner of the electric light and water-works power station were damaged. The tank was in the hands of the contractor.

FIRE TESTS OF GUASTAVINO TILE ARCH fireproof floors of 6, 10 and 12-ft. spans will be conducted under the supervision of the New York Board of Buildings at the northeast corner of Broadway and 108th St., commencing Thursday, May 9. These tests are intended to cover practically all of the possible loads that may be required of floor constructions by the Board of Buildings of Greater New York.

THE PALISADES INTERSTATE PARK COMMISSION, having already secured $50,000 and other valuable concessions from the New Jersey Legislature, will now have $400,000 from the State of New York by action of the late Legislature; $200,000 of this, however, will not be available until next year. The Commission is now engaged in securing the property along the Palisades, some 300 separate parcels of land being involved.

THE TAYLOR-WHITE TOOL STEEL, described in Engineering News of Aug. 9, 1900, appears, according to the patent specification, to contain chromium, tungsten and molybdenum in varying proportions. A comparison which is said to have given excellent results is carbon, 1.85; chromium, 2; tungsten, 8.50; manganese, 0.15; silicon, 0.15; phosphorus, 0.25; sulphur, 0.30.

BIDS FOR A 100-TON GARBAGE DESTRUCTION plant at Chicago will be received until May 24 by Mr. L. E. McGann, Commissioner of Public Works.

THE FRANCHISE TAX VALUATIONS FOR GREATER New York have been fixed for the year 1901 by the State Board of Tax Commissioners at an aggregate of $211,334,194, a decrease of some $8,345,000 from 1900. The three heaviest valuations are: Metropolitan Street Railroad System, $50,890,112; Manhattan Elevated, $44,407,500; Brooklyn Rapid Transit, $22,043,000.

FOR SEPARATING OIL FROM EXHAUST STEAM Mr. F. H. Boyer, in a recent paper, before the New England Cotton Manufacturers' Association, recommends a coke chamber, through which the steam is passed on the way to the condenser. Such chambers must be made strong enough to resist the external atmospheric pressure, and a cylindrical form is best. Any substance exposing a large amount of surface can be used to fill the chambers and catch the oil; but coke or any similar combustible substance can be emptied out and burned under the boilers, while broken stone or similar material must be cleaned after it becomes coated with oil.

A CONCRETE GASHOLDER TANK was built recently under the direction of Mr. C. W. Andrews, of Hamilton, O. The tank was 53 ft. in diameter and 25 ft. deep, both inside measurement, with its upper 10 ft. above the natural surface of the ground. A bank of earth 5 ft. high will leave only 5 ft. exposed. The walls are 30 ins. thick at the bottom and 23 ins. at the top. Mr. Andrews built a similar tank in 1897, and states since that date a much larger one has been built by Mr. D. Donald, of Louisville, Ky., using Louisville cement. Mr. Andrews used Portland cement for both his tanks. A paper describing his latest tank was read before the Ohio Gas Light Association, in March, 1901, and published in the "American Gas Light Journal" for April 8, 1901.

WOOD-PAVING IN LONDON is reported upon by U. S. Acting Consul-General R. Westacott. He says that the cost of creosoted yellow deal paving, laid on 6 ins. of Portland cement concrete, ranges from $2.43 to $2.92 per sq. yd. Australian hard-wood paving costs from $2.92 to $3.89 per sq. yd. The annual cost of maintaining the deal pavement ranges from 3 to 4 cts. per sq. yd.; but no reliable information on this head can be obtained for the hard wood. The Swedish deal blocks last from 7 to 8 years under heavy traffic, and 12 to 13 years on streets with light traffic. The specifications now demand that all such deal blocks shall be creosoted; the karri, or jarrah, hard-wood blocks are to be dipped once in boiling tar before laying and the joints run in with pitch and tar.

A 10,000-TON BALANCED SECTIONAL DRY-DOCK.

By Wm. T. Donnelly, M. E.*

(With two-page plate.)

HISTORICAL.

It will be well before going into a detailed description of the largest timber floating dry-dock that has ever been constructed to glance over the past history of the docking of vessels, so that a proper understanding may be had of the circumstances which have led up to the type of structure to be described.

Since vessels have been built, it has been necessary from time to time to remove them from the water to effect repairs and to clean off marine growths from their immersed parts. In early times this was effected by beaching the vessels on a shore where there was a sufficient fall of tide to leave the vessel bare and accessible. As vessels were built of larger size, this became impossible, and other means had to be found. Among these was the anchoring of a vessel securely in a sheltered place and by means of warping lines and purchase tackle bearing her over or capsizing her to such an extent that one-half of her underbody and her keel were brought above water. This method was a distinct advance over the beaching of vessels, as it gave opportunity for uninterrupted work which could be carried on without regard to the tide. The foregoing were methods that could be and were employed by the owners of vessels to care for and repair their own property.

The docking business as such began when commerce and shipping reached a point requiring vessels so large and in such number that their repair and cleaning became a profitable investment for capital and energy. The means employed were at first crude and simple, and the present methods are the outgrowth of many years of trial and experience.

The floating dry-dock is an American invention, the first patent being granted to J. Adamson on Dec. 13, 1816. This patent shows a wooden structure with a flat bottom and vertical sides. At one end were gates which could be opened (when the dock was sunk) to let the vessel in and which were then closed. The water in the interior could then be pumped out and the vessel repaired.

The sectional floating dry-dock seems to date from the patent of J. Thomas, Dec. 20, 1837, No. 522, which shows the first conception of distinctly separate sponsons and coupling logs, which are the essential features of a sectional dry-dock. In this dock the floats or sponsons were entirely immersed and guide frames were provided to maintain their stability while being pumped out.

W. Thomas, in 1854, added side wings to the sponsons, thus making the sectional floating dock complete and independent of any guides, supports or attachments to the shore.

Mr. Thomas's plans show a thorough and complete understanding of the problem. Each section, of which there are seven, shows independent means for pumping on each wing. He understood the principles of balancing the dock to prevent rolling by dividing it longitudinally by bulkheads and arranging to pump any compartment at will. The pumps of this dock were hand pumps. We find the first application of steam power to pumping a floating dock proposed in a patent to R. Porter under date of Nov. 14, 1835, but it is highly improbable that the Porter suggestion was ever carried out, as his arrangement seems a very impracticable one.

In 1854, S. Loveland patented certain improvements in the arrangement of valves and improved the dock by a form of transverse truss particularly adapted to distribute the strains.

The first application of steam power to the pumping of a sectional floating dock was by Dodge & Burgess under their patent of Oct. 9, 1841, and they were the first to meet and overcome the difficulty of transmitting the power between the different sections, a difficulty which arises from the constantly changing relative positions of the sections. The dock of Dodge & Burgess, while sectional, was only a semi or partial floating dock, as the sponsons were entirely immersed and guided by fixed supports to maintain the equilibrium of the ship and dock.

The inventions noted give the outline of the growth and development of the sectional floating dock and the dock of Thomas and Loveland of 1854, with the addition of steam pumping power, remained without substantial addition or improvement until the present time.

These docks were extremely popular during the period from 1840 to 1865, and until the construction of the dock described below, one of the Dodge & Burgess docks was the largest available floating dock at the port of New York. They were built up to eleven sections in length, or about 360 ft., and development along these lines would have continued but for the impracticability of handling any increased number of sections. The limit to the practical length of a section was found to be about 30 ft., and the extreme number that could be controlled with a reasonable degree of safety was ten or eleven, making the maximum length of the floating dock 330 to 360 ft.

Floating docks in one piece were built of varying sizes, but their limit in size was soon found to be less than the sectional dock and their cost more, and they possessed the very great disadvantage that it was impossible to remove the... from the water for repair.

From 1843 to 1900 no addition was made to the... size or capacity of the floating dock, sectional... otherwise, in this country, and the increase... length of vessels to 400, 500, 600, and finally... 700 ft., and in structural weight from 1,500... 10,000 tons, made possible but one method... docking, which has been by means of basin... graving docks.

Mr. Frederick C. Lang, the inventor of the La... balanced sectional dry-dock, commenced his ap... prenticeship in the business on the Loveland se... tional dock, and since that time has operated... kinds and sizes of floating docks, learning th... merits and advantages, disadvantages and da... gers of the various methods of docking vessels.

In July, 1891, the Tietjen & Lang Dry-Dock... Co. was formed, and in the succeeding years th... business has grown to be the largest of its kind in... the United States, and from a single floating dock... to six, and from the docking of a few small ves... sels to a capacity which is not equalled in this... country. Besides designing and building all the... docks which the Tietjen & Lang Co. is using, Mr.... Lang has built 17 sectional and other floating... docks which are now in use in various parts of the... country.

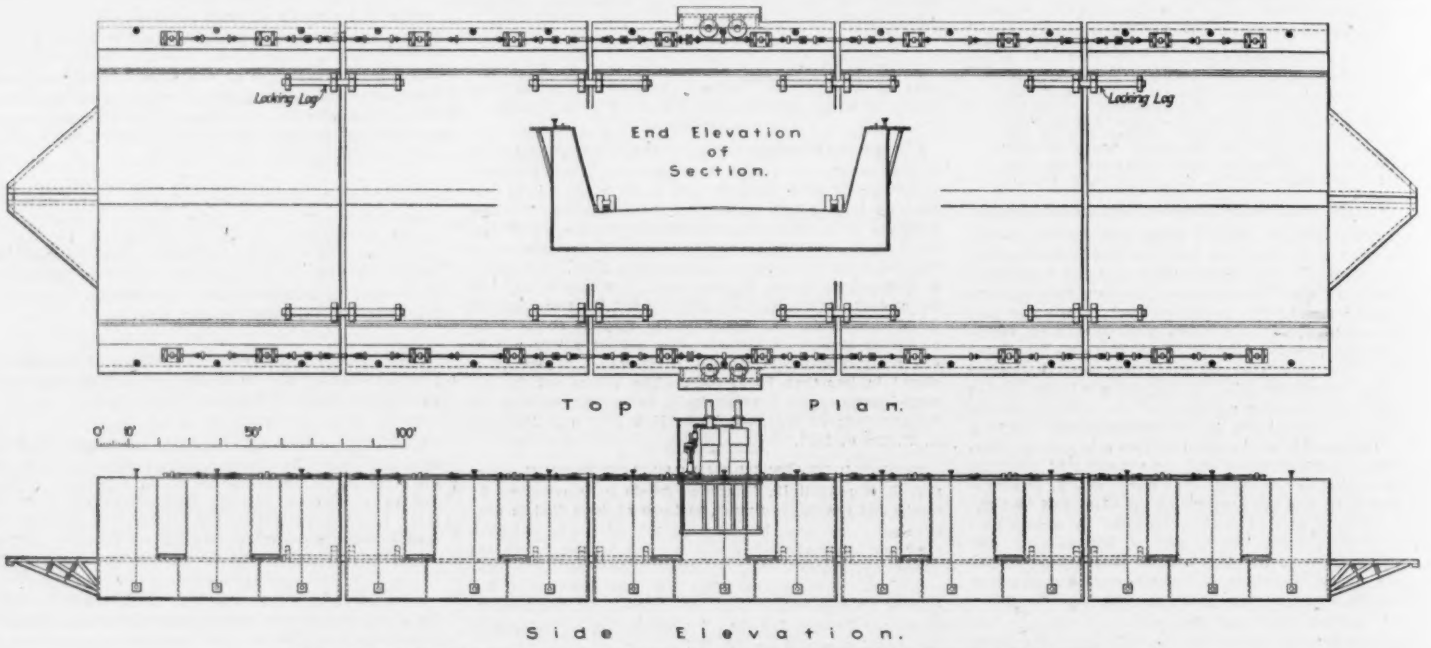

FIG. 1. PLAN AND SECTIONAL ELEVATIONS OF 10,000-TON SECTIONAL DRY-DOCK.

When, in January, 1898, Mr. Lang presented to us [Messrs. Faber du Faur & Donnelly.—Ed.] the general proposition to build a sectional floating dry-dock capable of handling vessels of 500 ft. in length and to have a maximum lifting capacity of 10,000 tons, which meant an increase in lifting power of about four times the capacity of anything hitherto built, we were more interested in the details of the problem than in the general proposition, and as we pushed our investigation we were pleased to find that our client had a keen insight into and a thorough understanding of the many conditions and difficulties presented.

DESCRIPTION.

The Lang balanced sectional dry-dock, as shown in Fig. 1, is composed of five sections, each of the following dimensions: 110 ft. 10 ins. wide, and 80 ft. long. When coupled together they are separated by 20 ins. and the section at each end has an overhang of 30 ft., making an overall length of 466 ft. 6 ins. The depth at the center is 13 ft. 6 ins. and at the waterways 12 ft. 6 ins. The height of the wings is 39 ft. 9 ins. The draft of the dock light is approximately 4 ft. 6 ins., the maximum draft which can be lifted 26 ft. and the maximum lifting power 10,000 tons. The available width between wings is 92 ft.

PUMPING MACHINERY.—The pumping machinery consists of duplicate sets on opposite sides

*Of the firm of Faber du Faur & Donnelly, 132 Nassau St., New York city.

of the dock, each composed of two 125-HP. vertical boilers operating engines with cylinders 20 ins. diameter and 24 ins. stroke, and making 150 revs. per min. Each engine drives a line shaft, which runs the entire length of the dock. These operate six pumps on each side of each section, or a total of 60 pumps. The pumps are 16 ins. square by 20 ins. stroke, and as they are driven by a reduction gear of one to two from the engine shaft, they make 75 strokes per minute. This machinery is designed to pump the full capacity of the dock in 45 minutes.

The sections are coupled together by what are known as locking logs, which connect the sections together through keepers, as shown in Fig. 1. These logs are of oak, 40 ft. long and 24 by 28 ins. in section.

The essential principle embodied in the Lang balanced sectional dry-dock and that which has made a floating dock of this size possible, is the manner in which the sections are divided into water-tight compartments. The separate sections in the previous sectional dry-docks were without transverse bulkheads, and any inclination of a section in a longitudinal direction would cause the water to flow towards the lower end and increase the difficulty of the unbalanced condition. In the Lang dock this has been overcome by building two transverse bulkheads in each section and providing independent means for pumping each compartment. This results in giving to the sectional dry-dock the desirable features of the present balanced dock, and at the same time retaining many desirable features of the sectional dock.

FIG. 9. WOODEN MODEL OF TRUSS OF DRY-DOCK.

STRUCTURAL FEATURES.—Referring to Fig. 2, the main features of the truss for this dock will be seen. In the center of the dock is a bulkhead built up solid of yellow pine timber 12 by 12 ins., and each side is divided into four panels by three longitudinal bulkheads extending from the bottom to the deck, but leaving sufficient space at the top and bottom for water communication between the compartments formed by these bulkheads and the transverse bulkheads previously mentioned. The truss proper is composed of a lower chord of 10 by 12-in. yellow pine timber. There are three diagonals or braces of 10 by 10-in. timber, each abutting at its lower end at the lower side of the corresponding longitudinal bulkhead. The two lower sets of braces at the center bulkhead abut against oak blocks, which were found necessary to distribute the strain to which they are subjected without raising the compression per unit of area of the center bulkhead dangerously near the crushing point. The upper set of braces abut at the center against one another and the center bulkhead is cut to allow this. Above the third brace is a continuous laminated arch, composed of three yellow pine timbers making an aggregate section 10 by 14 ins. This arch passes through each of the bulkheads and fits into the lower chord near each end. Above the arch and forming a deck beam is the upper member of the truss, which is a 10 by 12-in. yellow pine timber. This member is given a crown of 1 ft. to facilitate the flow of the water from the deck, and from the intersection of this member with the inner side of each wing run diagonals of 10 by 10-in timbers, to the end of the lower chord. The fitting of the braces and the arch into the lower chord is reinforced by anchor stocks which increase the section of the members at the point where the strain is transmitted and allow ample section for the fastenings. The arch is fastened by through bolts ¾-in. diameter and 1 ft. c. to c., and the fastenings of the brace are of ¾ and ⅞-in. galvanized drift bolts. The center and longitudinal bulkheads are drift bolted edgewise through 2½-in. planks. The floor timbers run longitudinally of the dock, and are 8 by 12-in. yellow pine placed on 30-in. centers. The bottom planking is 4 by 12-in. yellow pine, and runs transversely or across the dock. The deck planking, which is laid longitudinally of the dock, and directly across the upper member of the truss, is of 4 by 10-in. yellow pine. At the center of the dock five 8 by 12 in. yellow pine timbers are laid to carry the keel blocks, and these are gained 2 ins. over the upper member of each truss. At each side of the deck at its junction with the sloping side of the wing are two 12 by 12-in. timbers called waterways. Hold stanchions, or uprights, are of 6 by 10-in. yellow pine, gaining 5 ins. over all members where they intersect, and one is placed over each floor timber, alternating on each side of the truss. The trusses are on about 37-in. centers, or 26 trusses to each section. The design of this truss is entirely original with Mr. Lang, and properly proportioned it meets in a very remarkable way the peculiar conditions under which it operates. The maximum load to which this dock can be subjected is 24 tons per running foot or 72 tons per truss. But it is not the amount, but the peculiar manner in which the strains are applied that makes the problem of a suitable truss quite exceptional.

MACHINERY.—The choice of machinery for this class of dry-dock involved the consideration of a great many questions, and results were only arrived at by a series of eliminations. We were fortunate in this instance in having the guidance of all that had been done in and about these waters, and the requirements or conditions that the machinery must meet have been pretty well threshed out. Simplicity and reliability are of the first importance, and economy or efficiency which more often heads the list in large engineering work, is here the last thing to be considered. When it is understood that the machinery at the most will be used but one or two hours in the twenty-four, and more often only once in several days, the small importance of steam economy is apparent. Therefore, in selecting the type of engine, we chose the simple direct-acting vertical engine of ample power and of great strength and solidity. The boiler question was limited to such types as could be handled in the extremely limited room on the top of each wing, and the upright type with vertical tubes and submerged steam dome was considered to meet the conditions most satisfactorily. The question of pumps is one that is very broad, and after going over the ground carefully, we became thoroughly convinced that the type of pump which has quite generally been used on these docks, and which the Tietjen & Lang Co. used on all of their other docks, possesses qualities of simplicity and durability that cannot be excelled by more modern and perhaps more mechanical appliances. This pump, as shown in Fig. 3, is a square wooden box made of 4-in. oak planking 16 ins. square inside and about 14 ft. long, or reaching from the bottom of the dock up through the floor of the pump well a short distance above the deck. There are two of these pumps for every transverse compartment of the dock. They are single acting and each is provided with a foot valve near the bottom of the pump barrel, as shown in Fig. 4. The foot valve and plunger are made from the same pattern, and the details of construction are shown in Fig. 5. They are practically gridiron valves, with a rubber diaphragm, as will be readily understood from the drawing. The foot valves drop into a taper seat near the bottom of the pump barrel, and the plunger is attached to the lower end of the pump rod. The packing of the plunger is of 4-in. leather belting secured at its lower edge by rivets and free at its upper edge to press against the pump barrel. These pumps have been found to have exceedingly long life, and the parts to be replaced in case of wear or breakage are very simple and inexpensive. The pump rods are connected to a rocker arm, and on one end of this rocker arm is attached a connecting rod operated by a crank on the end of the shaft driven from the main line shaft, all as shown in Fig. 3. The pump rods are 4-in. I-beam section, the connecting rods 3-in. I-beam section. The boxes at the upper end of the pump rod and each end of the connecting rod are of bronze and are duplicates. The crank shaft and line shaft at the point where the reduction of speed is effected are carried in a common pillow-block, as shown in Fig. 3, and the bearings for both line shaft and countershaft are made from the same pattern shown in Fig. 6. By this means the distance between centers of the gear are accurately maintained.

The object of going into these details is to show the study that was made to effect the greatest possibe duplication of parts. In proportioning the machinery for the work to be done, a large factor of safety was used, as a break in any of the machinery during the lifting of a vessel might involve a loss of much time, which is very valuable in the case of large vessels. The great duplication of parts makes it possible to effect any repairs quickly and with very few parts on hand.

In Fig. 7 is shown the manner in which power is transmitted from one section to another, and the details of the parts used. When it is understood that a section may have a relative movement only limited by the locking log, and that this movement may be in any direction, it will be apparent that the connection must be both a universal joint and a slip coupling; a universal joint, so that the shaft may turn when out of alinement, and a slip joint so that the sections at this point may come together and separate without interfering with the transmission of power. As the slip coupling must operate under the strains of power transmission, it is necessary to provide a thrust bearing to each section. This was accomplished by securing a flanged hub to the shaft and bolting securely to the top of the dock a cast-iron plate or shoe which engages the flange of the hub and prevents longitudinal movement of the shaft. The slip joint was made of a square shaft, and all the parts of this joint and the universal joint are of cast steel.

In Fig. 3 are shown the floodgates and the stand for operating them and the details of the gate are shown in Fig. 8. The gates have an opening 12 ins. square, and the closing slide is made with a taper at each side of the back, so that when forced down by a rod it will be wedged tightly against its seat. The operating rod runs up through the side of the wing, and the gate is raised and lowered by a wheel operating a bronze nut on the upper end of the gate rod.

In operating the dock, the engine and all the pumps are running all the time, and the desired lift to correspond to the weight of a vessel over any compartment of the dock is obtained by a greater or less closing of the floodgate corresponding to that compartment.

TRUSS PROBLEMS.

Up to the present time all those who have had occasion to design trusses for this class of dock have proceeded upon the general theory that the maximum load to be borne by the truss was that due to the total weight of the ship distributed along the keel blocks at the center of the dock, and that the counter or supporting force was the distributed buoyancy over the under side or bottom of the dock,and that a truss designed to meet these conditions would be amply strong for the work to be done; meanwhile, it has been the common experience of the people handling these docks that when built with ample margin of strength to meet the conditions according to this statement of the problem, that they would in a short time show unmistakable signs of weakening when exerting their maximum lifting power and many attempts were made to strengthen them with poor success.

The careful observations of Mr. Lang, extending over a long period of time, supplemented by our own mathematical investigations, have brought out, we believe, for the first time, the remarkable and severe conditions under which a truss of this kind must operate.

In this class of docks (wing docks) the wings or sides have to be built high to admit of deep draft vessels over the keel blocks and to carry the large and heavy machinery used in pumping, also sufficient displacement or bulk must given to them to insure the stability of the dock and vessel. To overcome the buoyancy of the dock, it is necessary to load it with stone ballast, which is placed in the wings, amounting to 3 tons per running foot, or 400 tons per section, in the dock now under consideration.

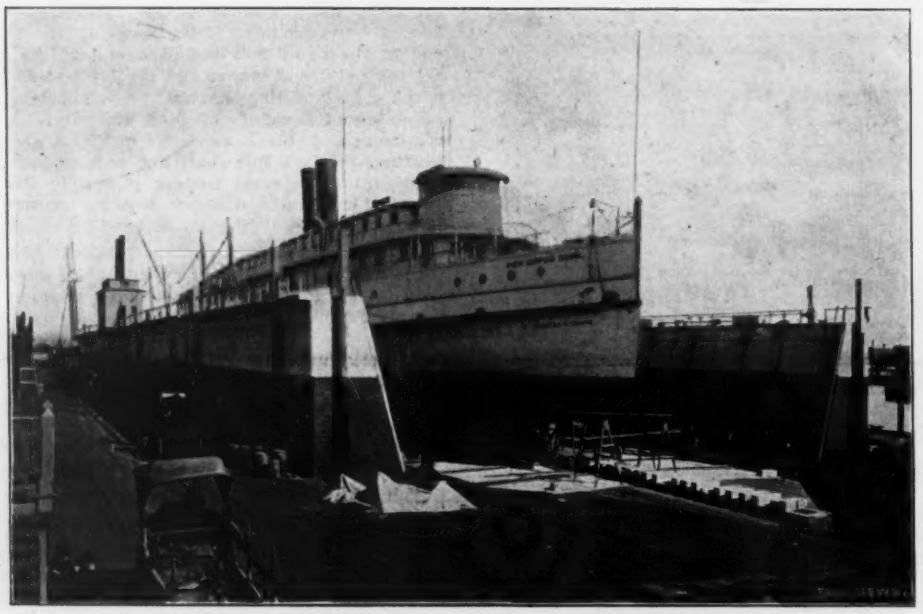

FIG. 10. SECTIONAL FLOATING DRY-DOCK IN USE.

With these points in mind and by the aid of the plans, we believe the real conditions of the problem may be readily understood to be as follows:

Starting with the dock down and a vessel over the keel blocks ready for docking, the sequence of conditions are:

(1) The interior and exterior levels of the water are about the same, as just enough ballast has been added to sink the dock to this level, and the dock is practically free from strains.

(2) The floodgates are closed and the pumps lower the interior level of the water, and the vessel is raised to a degree corresponding to the amount of water pumped out, but as the area of the wing is small relatively to the midship area of a vessel, corresponding to the maximum lift of the dock, the drop of the interior level of the water will be much more rapid than the rise of the vessel and dock out of the water, and the difference will continue to increase until the wings are pumped out down to the level of the body of the dock, when it will be about 16 ft., which will correspond to a buoyancy or lifting power of 6 tons per running foot of the dock for each wing, or 18 tons for each wing per truss.

The conditions of the loaded truss would now be 36 tons concentrated load at the center and a counter strain of 18 tons at points about 7t ft. from each end. With the proportions of truss here used, this would give a maximum strain at the center of the lower chord of 72 tons.

(3) From this condition there will be a rapid change, as the lowering of the water in the interior of the dock will be over its entire area, and as this is much greater than the area of the water line of the ship, especially as the immersed body of the ship decreases rapidly per foot of elevation; consequently, the difference of the interior and exterior levels of the water will rapidly grow less, the ship and dock raising much faster than the level of the interior water is lowered. This change will continue until the dock is entirely pumped out, when, if the lift has been to the maximum capacity, the deck of the dock will be just clear of the water, and the load upon it will correspond to the amount of displacement pumped out between the interior and exterior levels of the water at this time, less that necessary to float the dock at this level.

The conditions for determining the strains on the truss will now be as follows: A load at the center equal to the maximum lifting power of the dock and a counter strain or lifting force distributed evenly over the whole exterior of the bottom, just balancing the load and the structural weights for this position of the dock.

After careful investigation, we assigned the following structural weights to the dock for the length corresponding to each truss: For the body of the dock out to the commencement of the wings, 16 tons, and the weight for the wings are, structure, 8 tons; pumps and machinery, 9 tons; ballast immersed, 15 tons; total, 32 tons; and the displacement immediately below this we find to be 32.4 tons. This would be sufficient to support the structural weight and ballast of this part of the dock but for the fact that the weight of the ballast heretofore given is its immersed weight, and its weight, when the dock is entirely pumped out, will be greater by the amount of water it displaces; in this case 300 cubic ft., or 9.6 tons, and an amount of buoyancy corresponding to this must be deducted from the maximum lifting power of the dock. As a result, the maximum net load which the dock will carry is borne by that part of the truss between the wings, and in calculating the strains due to the load the ends of the truss below the wings are to be disregarded. Allowing for the structural weights of the central portion (16 tons) and for the necessary freeboard to work the dock, the net lifting power will be 62.4 tons and the strain at the center of the lower member of the truss 33 tons.

We will now consider another set of strains entirely different and of equal importance. These are brought about by the fact that it is necessary, after a vessel has left the dock, to pump it up light to rearrange the keel and bilge blocks. The pumping required to do this will be only that which will be necessary to bring the deck or floor of the dock above the water; this will require the elevation of the dock to the same height as at the previous pumping, but the conditions will be very different. We will have the same structural weights and the same distribution of them, but the weight which the dock previously supported will now be represented by water within the interior, and the difference of level between the water within the dock and on the outside will be that necessary to establish an equilibrium between the weight of the structure above water and the weight of the ballast less the buoyancy of the submerged wood.

We find the difference in interior and exterior levels to be 3 ft., which corresponds to an upward thrust of 32 tons, evenly distributed over the entire lower surface of the portion of the dock we are considering, but the structural weights and ballast are arranged very differently; the center portion between the wings contains no ballast, and has a buoyancy due to the material of its construction of about 6 tons, and the wings are of such weight, including the ballast and machinery, that they require the entire displacement of the portion of the dock below them to support their weight.

Therefore, under the present conditions, there is an upward thrust or force of 32 tons distributed over the entire bottom, due to the difference of interior and exterior levels of water, an additional upward thrust of 8 tons distributed over the part containing no ballast and a weight or downward thrust on the wings to counteract this.

To state this plainly and in its lowest terms, there is at this time a force tending to break the truss in the reverse direction to that hitherto considered. This strain amounts to 40 tons tensile force at the center of the continuous arched member, and this is the condition which the latter is designed to meet.

TIMBER AND FASTENING.

Besides these conditions, there is the important fact that the whole structure must be made and maintained watertight, or else the strength and integrity of the structure will be of no value for the purposes intended. It will be noticed that the bottom planking runs transversely of the dock, and the deck planking longitudinally, or at right angles. These are important features, first introduced in this dock; their value being that, as the lifting strain is applied, the tendency is to compress the deck planking and compress the seams, and that there is no tendency to open the bottom seams, as there would be if the planking, as heretofore, was placed directly upon the lower members of the truss in a longitudinal direction. We might say here that the calculations for the strength of the truss were based on the material in the truss proper, although it is very apparent that the planking as here used will add greatly to its strength. The outer corner of the sections where the lower members of the truss terminate is difficult to maintain, and it is believed that the arrangement here shown, in which the end of each lower chord has been dovetailed into the top of the corner log and into the bottom of the bilge log above it, is the best practical solution of the problem that has yet been obtained. The outer uprights for the wings are each 6 by 10-in. yellow pine and are dovetailed into the outer side of the bilge log and through-bolted to the 8 by 14-in. capping log, which is securely cross-bolted down through the end of each lower truss member and through the bilge log. The uprights for the sloping side of the wing are of 6 by 10-in. timber, and run by the truss members and are cross-bolted to them at the intersection. Braces and diagonals of 6 by 8-in. yellow pine timber are worked in the wing to receive the compression strains, and their vertical spacing is proportioned to meet the conditions.

As the length of the lower and upper chord members of the truss is greater than could be obtained in single lengths of yellow pine timber, it was necessary to go very carefully into the matter of scarfing or splicing, and a scarfing plan was worked out. The breaks were so arranged that they repeated or occurred at the same distance from the end of the truss on every fifth truss for the bottom chord and on every fourth truss for the upper chord. Each scarf was then through-bolted with screw bolts, and side splices of 4 by 12-in. yellow pine were drift-bolted to each side of the lower chord members, and on one side of the upper chord members.

The butts in all bulkheads were scarfed, and scarfing plans were laid out so that the butts were distributed to insure greatest strength. Plans were made showing planking of the main deck, side of wings and bottom, and the length of strakes were laid off and all the butts carefully distributed, so that the greatest variety in lengths of planking could be used and the best distribution of butts obtained. The bottom planking repeated breaks every eighth strake, as did also that for the sides of the wings and the main deck planking. From these detailed plans the length and dimensions of each piece were obtained, and it was possible to make a bill of lumber that was accurate and complete for the material of one section, and this bill was used in getting out the lumber by the lumber mills in the South in precisely the same way as a bill of material is used by the rolling mills for structural iron.

THIRTEEN YEARS' EXPERIENCE WITH MUNICIPAL STREET LIGHTING AT CHICAGO, ILL.*

By Edward B. Ellicott.†

After an experience of 13 years in owning and operating a municipal lighting plant for street lighting purposes, it is proper that the city should furnish to the citizens some definite statement as to the results obtained and benefits derived by the city from the service which it has been furnishing under varying conditions, and that a comparison be made between the results obtained and those that might have been secured by renting from private corporations the service which it has elected to furnish under municipal ownership. The length of time the system has been in operation is sufficient to give a practical test of municipal ownership of street lighting systems, and this length of time should settle for once and all the perplexing problem of depreciation.

In order to avoid all argument and difference of opinion as to what percentage should be added to the cost of operation on account of depreciation, the total amount of money paid out for construction, operation, repairs and renewals of all kinds during 13 years will be placed in one bulk sum. By this means we will arrive at the total amount of money that the electric light system has cost the city of Chicago, regardless of whether it was expended for the purpose of operating, repairing, constructing and providing for depreciation on all parts of the electric lighting system. Against this total sum we will place the total amount of money that the city would have paid to private corporations for the same service which it has been furnishing on account of the construction and operation of its municipal system. By this means we can make an exact comparison between a municipal lighting system which has been in operation for a period of 13 years and has passed through varied stages of improvements in electric light apparatus, subjected to all the depreciation that any private plant could be, and has also felt the effects of six changes in city administration.

A careful examination of the comptroller's reports, reports of the department of public works, fire department and department of electricity under the management of which the system has passed from time to time, show that the total amount of money paid out for the purpose of constructing, operating, repairs and rebuilding, due to depreciation, is $2,786,100. With this amount of money the city has built the necessary plants and has furnished upon the streets of the city, during the period of 13 years, a number of lights varying from a small beginning of 192 lights in the year 1888 to a maximum number of 4,239 lights on Jan. 1, 1901.

To obtain the amount of money the city would have paid for lights rented from private corporations at prevailing prices during corresponding years, between 1887 and 1901, the average number of lights operated by the city for each year has been taken at the rate the city was paying or would have paid for rented lights during the corresponding years. This service would have cost the city $2,507,111. We must also add to the total cost of the city plants an item of interest on the difference between these two amounts from year to year. It would not be fair to charge interest on the full amount invested by the city, for the reason that if it had not invested money in its plants for construction and operation it would have been obliged to rent lights from private companies, which would have been a similar investment. The difference between the amount the city has paid on account of its plants and that which rented lights would have cost varies from year to year, as shown by a comparative table, consequently to the total cost of maintaining and operating the lights we should add interest on this extra investment over and above what rented service would cost. This amounts to $189,961 during a period of 13 years.

Inasmuch as we have taken care of the depreciation in the bulk sum we can properly eliminate a further charge for any specific year. The difference between the amounts as given for the cost of rented service ($278,990) plus the interest on the extra investment ($189,961) on account of the municipal ownership, shows plainly that the plants, as they now exist, have cost the city $468,951. The following is what the city of Chicago has to show for this extra investment:

Over 125 miles of conduit and cable system, as serviceable as when new, which could not be replaced for	$350,000
Three power plants having a dynamo and engine capacity of 4,700 lights, which could not be duplicated for	352,000
4,400 arc lamps with aerial construction and posts, all of which are practically as good as new and could not be replaced for	154,000
Two power stations with real estate, which are not in service at the present time, worth	65,000
Total valuation	$921,000
The system inventories	$1,350,000

This total valuation of $921,000 less the amount invested in excess of the cost of renting lights, represents a clear profit to the city of $452,050, during its 13 years of municipal operation. It also represents a forced reduction on the prices paid for rented lights, which would never have been secured without the operation of the municipal lighting plant. Up to 1897, when the city had in operation a total of 1,254 arc lamps, the total cost of construction and operation was not as favorable for comparison with what rented lights would have cost, but the extensive increases in the system make it possible at this time to show a very decided reduction in the relative cost of furnishing arc lights under municipal ownership and renting from private corporations.

For instance, during the year 1900 the city operated an average of 3,867 arc lamps, at a total cost of $265,129, which includes an $18,750 interest charge, and over $10,000 on account of depreciation, while to have rented these lights at the lowest price quoted to the city would have cost $458,021, leaving a total net saving of $192,891 for the year 1900. There is no reason why an equally good or better record will not be made in 1901.

No consideration has been given for the taxes that might have been paid to the city had this same investment been owned by a private corporation. It is impossible at this time to estimate what might have been so paid by a private corporation owning and operating this system, but based on what a large corporation paid during 1900, the amount for this year would have been $9,490.

In two years more the city of Chicago should not owe itself one cent on account of the plants that it has built, or valuable property it has acquired in constructing the plants, for it will have saved enough over and above what it would have paid for rented lights to build and operate the plants as they now exist.

This is a practical business statement of the results obtained by the city, and should receive more consideration than the theoretical statements of private corporations, which have never in one single instance published the figures showing the itemized cost of producing an arc light under private control. In order to show that the city is not producing a light at the costs which are published they find it necessary to add a false interest charge and a false theoretical depreciation charge, so that the cost to the city may nearly equal the price which they charge.

Their arguments should have no further weight with the general public until they produce for inspection and criticism the items that make up their actual cost of producing light of a similar kind, and on the same basis.

Tables are presented herewith showing the development of the system and the amount expended in operation and construction from year to year, and a comparison between each of these years, with the amount of money the city would have been obliged to pay private companies for the service which it furnished from the plants.*

A table is also furnished showing the total amount expended at the end of each year of the term in building and operating its plants, and a comparative table showing the gross sum at the end of each year that the city would have paid for an equal number of rented lights; and further, a table showing the difference between the amounts expended by the city for building and operating its plants, and the amounts it would have paid to private companies for the same service; also the interest for the excess sum invested by the city each year is set opposite. By this means of figuring the interest we arrive at the total of interest that the city would have paid during the 13 years on the excess money which it has invested in the building and operating of its municipal plants.

All available records have been searched in order to obtain both the accurate amounts expended by the city and prices which rented lights would have cost. In considering the cost of rented lights throughout the term of years, it must be remembered that up to 1898 the city of Chicago placed all of its wires underground. After that date some lamps were placed overhead, and they are charged against rented lights at the lowest figure we could obtain for that service, which was $105 for two years and $103 for one year. The lowest price ever made for rented lights on underground circuits was $137.50. The city of Chicago might receive lower prices for rented lights if a contract could be made for a longer period than one year. This it cannot do, and while it is an argument in favor of the prices quoted by private companies, it is also an argument for the municipal ownership of public lighting systems.

*An official report. †City Electrician, Chicago, Ill.

THE PROGRAM FOR THE U. S. GEOLOGICAL SURvey is announced for the next fiscal year. An important feature will be the re-running and marking of parts of the northwest boundary between the United States and Canada, from the summit of the Rocky Mountains westward, the work to be done in conjunction with the Coast and Geodetic Survey. The boundary of Idaho and Montana is also to be run to ascertain its geological features and the condition of the monuments. The gas wells of Louisiana, the lead and zinc deposits of Missouri, the gold deposits in Georgia, and the devonian and carboniferous strata of New York are to be investigated. Topographical surveys of States will continue in co-operation with State surveys.

THE ASSOUAN DAM, on the Nile, is rapidly approaching completion. U. S. Consul General John G. Long, of Cairo, sends the following statement of progress: All the 150 low-level sluices are practically completed, and the most important work now in hand is the building of the dam across the western channel, the last of the five deep channel crossings. All of the foundation masonry should be above normal water level before the beginning of the Nile flood of this year. At the First Cataract a canal is being built which will be 6,540 ft. long and have four locks, each 31 ft. wide and 261.6 ft. long. The foundations of all these locks are in place and the canal is progressing rapidly. The cost of this canal is approximately $1,250,000, and the original estimated cost of the two great dams, at Assouan and Assiout, and the canal and subsidiary works, was $9,886,000. The actual cost will greatly exceed this sum, but the whole work will be finished in 1902, or in four instead of five years. The contractors are Messrs. Aird & Co. Sir William Garstin, in his report to Lord Cromer in 1897, estimated that the annual wealth of Egypt will be increased $12,851,800 by the construction of these reservoirs, and the direct gain to the government will be nearly $1,878,340 per year under the least favorable circumstances. The value of government land reclaimed will be nearly $5,000,000.

*The tables mentioned have been combined in one.—Ed.

Expenditures for Chicago Municipal Street Lighting Plant, Compared with Estimated Cost Under Private Contract.

	Yearly outlay for renewals and operation.	Total amount paid by city.	No. of city lamps.	Cost of lamps, if rented. Per lamp.	For year.	To close of year.	Extra expenditure, account of city ownership. Yearly balance.	Interest on balance at 4½%.
1887	$39,976*	$39,976*	...	.....	.....	.....	.....	.....
1888	90,953	130,929	192	$200.00	$38,400	$38,400	$92,529	$4,164
1889	331,617	464,546	297	185.00	54,945	93,345	369,201	16,614
1890	214,331	676,876	900	175.00	157,500	250,845	426,031	19,171
1891	214,952	891,828	993	175.00	173,775	242,620	467,208	21,024
1892	134,674	1,026,503	1,102	175.00	192,850	617,470	409,033	18,406
1893	168,169	1,194,672	1,112	156.25	173,750	791,220	403,452	18,155
1894	174,143	1,238,815†	1,108	137.50	152,350	943,570	296,245	13,330
1895	180,330	1,419,145	1,116	137.50	153,450	1,097,020	322,125	14,496
1896	144,078	1,563,223	1,254	137.50	172,425	1,269,445	293,778	13,220
1897	152,493	1,715,716	1,438	137.50	197,725	1,467,170	248,546	11,185
1898	289,483	2,005,199	1,710	272 at $105.00 1,438 " 137.50	226,285	1,693,455	311,744	14,028
1899	347,377	2,352,576	2,893	1,297 " 105.00 1,596 " 137.50	355,635	2,049,090	303,476	13,656
1900	433,524	2,786,100	3,867	2,136 " 105.00 1,731 " 137.50	458,021	2,507,110	278,989	12,555
Total interest charge for 13 years on extra investment								$189,961

*Construction only. †Less one plant sold in 1893, and transfer to real estate.

ELECTRIC POWER STATION OF THE VIRGINIA ELECTRICAL RAILWAY & DEVELOPMENT CO., RICHMOND, VA.

Among the larger of the electric power plants now being developed in the South is one on the James River, at Richmond, Va. This plant, which will have at the start a nominal water power capacity of 5,000 HP., was begun on June 1, 1899, by the Virginia Electrical Railway & Development Co. The first generator was turned by water power on Feb. 20, and the first steam engine tested on March 15, 1901. Mr. Reuben Shirreffs, M. Am. Soc. C. E., is the engineer for the work, and we are indebted to him for the following information given to a member of the editorial staff of this journal while on a recent visit to Richmond. The James River Construction Co. is the contractor for the entire plant and canal. The company has sublet the work in part as follows: Construction of dam, canal and power house foundations, Winston & Co., Chicago; turbine wheels, Stillwell-Bierce & Smith-Valle Co., Dayton, O.; generators, General Electric Co., Schenectady, N. Y.; steam engines, Edw. P. Allis Co., Milwaukee, Wis.; boilers, Babcock-Wilcox Co., New York city; piping, T. C. Basshor & Sons, Baltimore, Md.; siphon jet condensing outfit, H. R. Worthington, Brooklyn, N. Y.

The power house is located on the site of the once celebrated Haxall-Crenshaw flour mills, buildings some six stories in height, which were taken down by the present owners. The James River has a fall, just above tide water at Richmond, of 105 ft. in a few miles, of which the location named utilizes about 25 ft.

A new concrete masonry dam, about 1,700 ft. long, has been built, with an average height of 5 ft. above the bed of the river and a maximum height of about 8 ft. A dropping timber crest will be used to maintain the river level 4 ft. higher. During freshets this timber will be hoisted above the water to avoid flooding property up the stream. It consists of a series of gates or shutters, curved vertically, hinged to concrete masonry piers at the center of this curve so as to avoid any effect of the water pressure to hold them either up or down, and raised and lowered by mechanism on a car, which will move from bay to bay on a track supported on these piers. Electricity will be used to drive this mechanism. The piers are 40 ft. c. to c. and are 4 ft. thick, 12 ft. wide transversely of the dam, and the track is about 13 ft. above the permanent or masonry crest.

An old canal has been enlarged from an average cross-sectional area of some 250 sq. ft. to 650 sq. ft. (50×13 ft.) for the 1,200 ft. nearest the power station, and to 1,200 sq. ft. for the upper portion, which is 900 ft. long. The lower and smaller section has side walls and a bottom lining of concrete, but in the upper section the sides and bottom remain as cut from the rock.

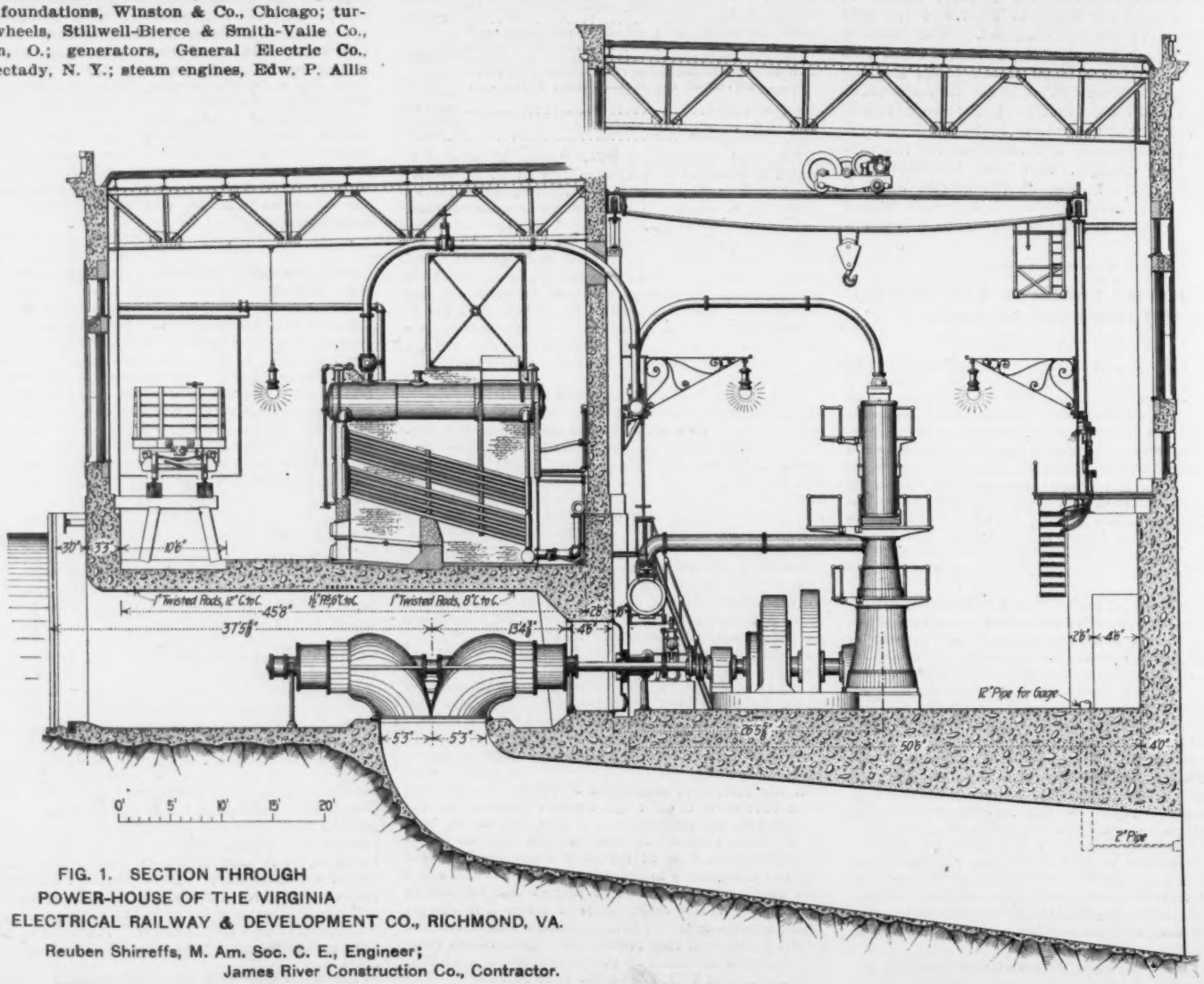

FIG. 1. SECTION THROUGH POWER-HOUSE OF THE VIRGINIA ELECTRICAL RAILWAY & DEVELOPMENT CO., RICHMOND, VA.

Reuben Shirreffs, M. Am. Soc. C. E., Engineer;
James River Construction Co., Contractor.

Fig. 1 is a section through the power house, on the center line of one of the power units. Fig. 2 is a general view of the power house under construction. The piers in the river are a portion of the terminal improvement work of the Chesapeake & Ohio Ry., described in our issue of Nov. 29, 1900. Fig. 3 shows the last turbine, just in place.

The power house will be 110 × 300 ft. eventually, but the portion already constructed is only 110 ft. sq., the unit spacing being 22 ft. c. to c. Concrete has been used not only in the dam and canal, but in the power house foundations, walls, chimney and roof. Beneath the boilers and coal track (both of which are carried over the wheel chambers) and in other places where special strength was required, twisted steel rods, on the Ransome system, have been placed in the concrete.

Under the machine room the entire area below the floor was filled with concrete solidly to the rock except the draft tubes leading the water from the turbine wheels. These draft tubes are 10[illegible] ft. in diameter at the wheels, and 14 ft. at the discharging end. The turbine wheel chambers are 18 ft. wide in the clear, covered with semi-circular arches, with crown 4 ft. below the canal level. As noted above, the boiler room, with its coal track and appurtenances, is carried on the arches.

The concrete used was of three classes: No. 1, 1:2½:4½, with Portland cement. No 2, according to the specifications, was to have been 1:2½:5, natural cement, but after beginning the work 1:3:7½ Portland cement was in great part substituted therefor, a small addition being made to the contract price, as it was found unsatisfactory to work the two cements together, principally on account of the difference in the time of setting. No. 3 was 1:2½:5 natural cement. The packed bulk of cement was used to determine the bulk of sand and stone.

No. 1 concrete was used for the piers and arches of the wheel chambers; for 2 ft. thickness around the draft tubes, measured radially; for the entire filling around these tubes for a strip 10 ft. wide longitudinally of the machine room under the engines; under all superstructure walls; and for the finishing layer of all floors.

No. 2 was used for the greater part of the canal walls, and for the spandrel filling of the wheel chamber arches.

No. 3 was used for the spandrel filling over the draft tubes in the machine room, where there were no heavy weights, and to level up the inequalities of the canal bottom. It may be stated here that the canal enlargement was largely rock excavation, and large quantities of rock were also

FIG. 2.—VIEW OF POWER-HOUSE FOUNDATIONS UNDER CONSTRUCTION.

excavated under the power house foundations and in the tail race.

The concrete blocks used for the power house walls, above the ground level, were made of No. 1 concrete, moulded in boxes and laid up in the walls in courses like stone ashlar. The concrete block plant was under cover. The work was carried on in winter, fires being kept up to keep the air fairly warm and to heat the mixing water. Slight freezing seemed to do no harm, but it naturally delayed the setting. Except in very cold spells, and the thermometer went down to 12 or 14° F. at times, the blocks could be removed from the boxes and lifted in 36 to 48 hours after moulding. In warm weather this period was 24 hours, or even less. The blocks were handled by irons inserted entirely through the stones, through holes left for the purpose, the irons being turned 90° after insertion to engage shoulders formed on them. As it was necessary to lift the stones before they had acquired much strength, thin iron straps were imbedded near the bottom face to distribute the weight. A few stones were broken by lifting them out of the boxes too soon in cold weather. The cornices, base courses, window stones, and the like, were moulded to the desired forms, and rather more attention was given to architectural effect than is usual in this class of buildings.

The exterior shell of the chimney is of concrete, for its full height, with an inner shell of brick, with an air space between the brick and concrete. The flue is 11 ft. in diameter and 175 ft. in height, above the grate surface. The exterior of the chimney is octagonal, the diameter of the inscribed circle being 19¾ ft. at the roof line, and 14½ ft. at the top.

The roof of the power house is on a flat slope. Steel trusses and purlins support the concrete covering, reinforced with expanded metal, and this is covered with asphalted paper and slag.

The chief feature of the contractor's plant were a 400-ft. Lidgerwood cableway, extending the length of the power house; two Gates' crushers, two Carlin cubical box concrete mixers, an air compressor driven by water power and two stiff leg travelling derricks, one of which was used to handle the excavation of the canal, and the other on the excavated bottom of the canal to handle the concrete for the walls and bottom lining. Several large "bull wheel" derricks were also used.

The initial installation of machinery comprises four pairs of Victor wheels 51 ins. in diameter, each pair or unit giving about 1,250 HP. under the 25-ft. head; four direct connected 750 K-W. direct current generators of the railway type, 550 volts at no load and 580 volts at full load; three steeple tandem compound condensing engines rated at 700 HP. at best economy, but capable of being pushed to 1,500 HP.; a jet condensing apparatus of the automatic siphon type, capable of handling 6,000 HP.; and two batteries of Babcock & Wilcox boilers, each battery having six 3½-ft. steam drums, and rated at 1,000 HP. each.

The company has also installed an extensive underground wire system. The trunk conduit from the power house to Main St. contains 64 ducts, each large enough to carry two large or three small cables. On some of the minor streets Edison tubes only are used, the principal service in such cases being electric lighting. Incandescent lamps of 235 volts will be used.

Among the large customers with whom the Development Co. now has contracts is the Richmond Traction Co., owning one of the two street railway systems in Richmond; The Richmond Locomotive & Machine Works, and the Wm. R. Trigg Co., shipbuilders, both of which companies are now engaged in making extensive additions to their works. Besides these large consumers the company expects to supply many small factories and motors, and it will, of course, get at once a considerable lighting load.

WOODEN FORMS FOR CONCRETE WORK.

The best methods of constructing forms for concrete work were described as follows in a paper by Mr. C. R. Neher, read before the Engineers' Society of Western New York on March 5:

To produce smooth work the addition of granolithic face, or plastered surface is unnecessary, smooth forms, with concrete well proportioned will give just as smooth work at much less cost, leaving the whole mass uniform, without a line of separation, or different compressive strength. Another way to produce finish is to joint the concrete to represent masonry, using rough lumber for forms, then bush hammering the face, which can be done by an ordinary laborer at 1½ cts. per sq. ft., the amount saved by using rough lumber going a long ways towards paying for the bush hammering. This removes all impressions from inequality of moulds, efflorescence, etc.

The preparation of forms calls for considerable ingenuity, and every contract requires special study, to the end that smooth surfaces be left, with unbroken corners, that the swelling of the wood does not rupture the concrete or leave distorted surfaces, and that the forms be so designed as to be used several times, and readily set up and taken down, and later on converted to other uses. As the charge for forms against the concrete can seldom be kept below 50 cts. per cu. yd., for heavy work there is always an opportunity for careful plans, and all depends on the ingenuity of the designer, as few rules can be laid down for his guidance. The use of matched, or tongue and grooved stuff is not desirable, as concrete fills in the openings and there is no opportunity to expand from moisture, unmatched boards dry apart and let the water in the concrete leak out, carrying with it some of the cement, later on they swell and buckle, and if used as interior forms burst the concrete, the best way devised so far is to bevel one edge of the boards, using narrow stuff, not to exceed 6 ins., the sharp edge of the bevel lying against the square edge of the adjoining board allows the edge to crush when swelling, closing up the joint, and preventing buckling.

A coat of soft soap before filling the forms prevents the concrete from adhering to the forms, which should always be scraped and brushed with a steel wire brush when taken down.

Square corners should be avoided as they readily slip off, and where used as interior forms for recesses or cellular construction, a fillet should always be placed in the corners.

A COMPARATIVE TABLE OF OCEAN STEAMSHIPS is given by "The Engineer," of London, in connection with a notice of the late launch of the "Celtic." This table is as follows:

Vessel.	Length, ft. in.	Breadth, ft. in.	Depth, ft. in.	Gross tonnage, tons.
Great Eastern	691.0	82.8	48.2	18,915
Britannic	468.0	45.2	33.7	5,004
City of Rome	600.0	52.3	37.0	8,144
Alaska	520.0	50.0	38.0	6,400
Etruria	520.0	57.3	38.2	7,718
Paris	560.0	63.2	39.2	10,500
Teutonic	582.0	57.8	39.2	9,984
Fürst Bismarck	520.0	57.6	38.0	8,874
La Touraine	540.0	56.0	34.6	9,209
Campania	620.0	65.0	43.0	12,950
Kaiser Wilherm der Gr	648.0	66.0	43.0	14,349
Oceanic	705.0	68.0	49.0	17,274
Deutschland	686.0	67.0	40.4	15,500
Celtic	700.0	75.0	49.0	20,880

FIG. 3. THE LAST TURBINE IN PLACE.

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AND
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ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXI-XXIII. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

The benevolent purposes of the United States Steel Corporation toward consumers have had a new illustration this week in an advance of $2 a ton in the price of standard steel rails. At the former price of $26 a ton, the profits on the present year's output of rail mills controlled by the U. S. Steel Corporation was recently estimated at $12,500,000. This advance in the price of steel rails is made in the face of a reduction of $1.25 per ton for iron ore over last season's prices. It is also not without interest in this connection to note that the net profits of the U. S. Steel Corporation during the first month of its operation are reported to have exceeded a rate of $111,000,000 per annum. This is roughly equal to the total dividend payments by all the railways in the United States in 1900. This advance in the price of rails affects chiefly the large railway companies which carry a heavy traffic and require a considerable tonnage annually for rail renewals. The recent development of the "community of interest" idea has been such that the same financial interests which control the steel industry also dictate the policy of not a few of the railway companies. Under these circumstances large railway orders may be placed for rails even though the price does mount skyward. It does not follow, however, that the railway stockholders who are not on the inside of the steel corporation will suffer. The increased price of rails has already been urged as a valid reason for raising freight rates, and in this manner the dear public has to foot the bill.

A bridge is likely to span the Hudson River at New York city before many years, but it will not be located at Fifty-ninth St., where the New York & New Jersey Bridge Co. has projected a structure. During the past week, the agitation over the bill granting to that company a franchise for an elevated railway along the North River water front of New York (perhaps also girdling the entire city), has brought the real facts regarding the North River bridge situation prominently before the public.

In a nutshell, the railways now having terminals on the Jersey side of the North River have no use for a bridge located at Fifty-ninth St. As was fully explained in an editorial in this journal some years ago,* freight can be brought onto Manhattan Island more cheaply by the present system of car floats than by any bridge and system of terminal tracks which it is possible to build. One class of traffic, and one only, can make a North River bridge profitable, and that is the passenger traffic from the New Jersey suburbs of the city, now approaching half a million in population. A bridge at Fifty-ninth St. is located much too far north to accommodate this traffic. The project to build a bridge at this point, therefore, is nothing more than a promoter's dream. It can be confidently predicted that any who invest in such an enterprise will suffer loss.

Besides this, it is officially stated that the North River Bridge Co., whose president is Mr. Gustav Lindenthal, M. Am. Soc. C. E., has secured the powerful backing of the Pennsylvania R. R. and of other important railways terminating on the water front opposite New York; and that work will be commenced within 18 months on a bridge for railway passenger traffic only, crossing the North River by a single span below 23d St., two miles or more south of the New York & New Jersey bridge location.

So much for the bridge scheme. Now let us turn to another aspect of the case. While the New York & New Jersey Bridge Co. urges its franchise for a West St. elevated railway, ostensibly as an approach to a bridge, there is nothing to hinder that company from building and operating the elevated road alone, or from selling its franchise for such a road to the Manhattan Ry. or to any other corporation. Would an elevated railway for either freight or passenger traffic or both, encircling the water front of Manhattan Island, be of advantage to New York city? Opinions on this point differ. A board of engineers some years ago proposed such a structure as a means of facilitating the movement of freight on the North River water front; but the plan was condemned as impracticable by other engineers, and especially by so competent an authority as Mr. C. W. Buchholz, M. Am. Soc. C. E., Chief Engineer of the Erie R. R., whose practical experience in transportation matters under the conditions that obtain at New York city gives his opinion great weight.

Admitting, however, for the sake of argument, that such a railway might be desirable, it does not follow at all that such a franchise as that which the New York Legislature has just granted ought to be approved. This franchise is perpetual; it has the vaguest and loosest limitations; it gives to a private corporation a monopoly of communication with the enormously valuable dock property owned by the city. Should the city at some future date desire to have just such an elevated road constructed as is proposed by this franchise, it might find the holders a veritable dog in the manger and be compelled to buy them off; just as a few years ago the owners of an East River Bridge franchise, which the Legislature had unwisely granted, had to be bought off before the city could build the structure. These circumstances fully justify the strong protests against the franchise presented to Gov. Odell on April 30, and it is to be hoped will induce him to withhold his approval.

Thirteen years of experience with municipal electric street lighting at Chicago is reviewed elsewhere in this issue. The method adopted for this purpose by Mr. Edward B. Ellicott, City Electrician of Chicago, is to set against the actual yearly outlay for construction, renewals and operation, the sum which the city would have paid during the same year if it had rented lights of a private company. He foots the two columns yearly, thus making a new balance for each year, and computes interest on each year's balance. The balance for the thirteenth year, plus the sum of the yearly interest charges, he considers as the total cost of municipal ownership to the city. Then against this he puts the estimated value of the plant itself. By this plan it appears that the city will have an extensive street lighting plant in a few years, paid for out of the difference between the cost of municipal and private service.

Much might be said both for and against this method of comparing the cost of public and private street lighting. Some of the points both pro and con, are discussed by Mr. Ellicott. One thing he does not point out is the seeming laxness of a great city like Chicago in not securing legislation that will permit it to make contracts for more than one year at a time for such public services as street lighting and garbage disposal. Obviously the yearly contract system means unnecessarily high prices. Another point which the report does not mention, but which is suggested by the figures, is that if the city is really paying for an electric lighting plant in so short a time as the calculations presented indicate, somebody is having to foot a relatively heavy bill meanwhile for the benefit of future consumers. This does not necessarily detract from the benefits of public ownership, but suggests the question, are the capital charges being liquidated too rapidly? Whatever the merits of this yearly balance method of comparing the cost of public and private owenership may be, it would be interesting, and perhaps instructive, to see a statement, year by year, of the actual outlays for new construction, capital charges, renewals, and ordinary operating expenses, each given separately. What amount of street lighting bonds, if any, are now outstanding, and what rate of interest do they bear? Have the amounts expended for renewals kept pace with the natural deterioration of the plant, or should something be written off for depreciation? In other words, supposing the city of Chicago had transferred its street lighting plant to a private corporation on Jan. 1, 1901, what price could it have obtained for it, and what portion of that sum would have been required to pay off the bonded indebtedness on the plant; in the shape of either specific lighting bonds or general funded debt incurred on account of street lighting?

Knowing that the city of Chicago is hampered by charter and constitutional provisions, a proof of the foregoing note was submitted to Mr. Ellicott in order that he might have an opportunity to show the bearing of the restrictions named upon the street lighting question. He has kindly submitted the following explanatory and other comments on some of the points raised:

As to the seeming laxness of the city in not securing legislation that will permit it to make contracts for more than one year at a time for such public services as street lighting and garbage disposal, I would say that the city has made sufficient efforts to do this, but the courts have decided that it is impossible without a constitutional convention, together with the amendment of the present charter of the city. Mayor Harrison has devoted a great deal of time toward securing an amendment of the charter, and all of the civic bodies of the city are using every effort in their power to secure the same result, but it is questionable if their efforts will be successful.

Your comment on the fact that the citizens are obliged to foot a relatively high bill in the installation of the plants, much of which will be used for the benefit of future residents, is very apt. This is a condition brought about by the present condition of the charter, which makes it impossible for the city to incur any further bonded indebtedness. This limit of bonded indebtedness is fixed by a percentage of the assessed valuation of the property, and the absurdity of it appears when the fact is presented that we can issue less bonds now on this basis than could have been issued ten years ago, consequently all extensions to municipal lighting system must be paid from the annual tax levy. The city has never issued one dollar of bonds or incurred one dollar of indebtedness in the building of its electric lighting plants. The entire work has been done from money appropriated from the general tax levy. The amounts expended for renewals have more than kept pace with the natural deterioration of the plants, as they are in better condition to-day than they have ever been. Notwithstanding this fact the statements show that while the plants are inventoried at $1,350,000, they have only been considered as worth $921,000. In other words, in making these figures we are practically allowed $429,000 on account of

*Engineering News, Nov. 25, 1897, p. 345.

FIG. 7. DETAILS OF UNIVERSAL TOGGLE JOINT AND SLIP COUPLING FOR LINE SHAFT.

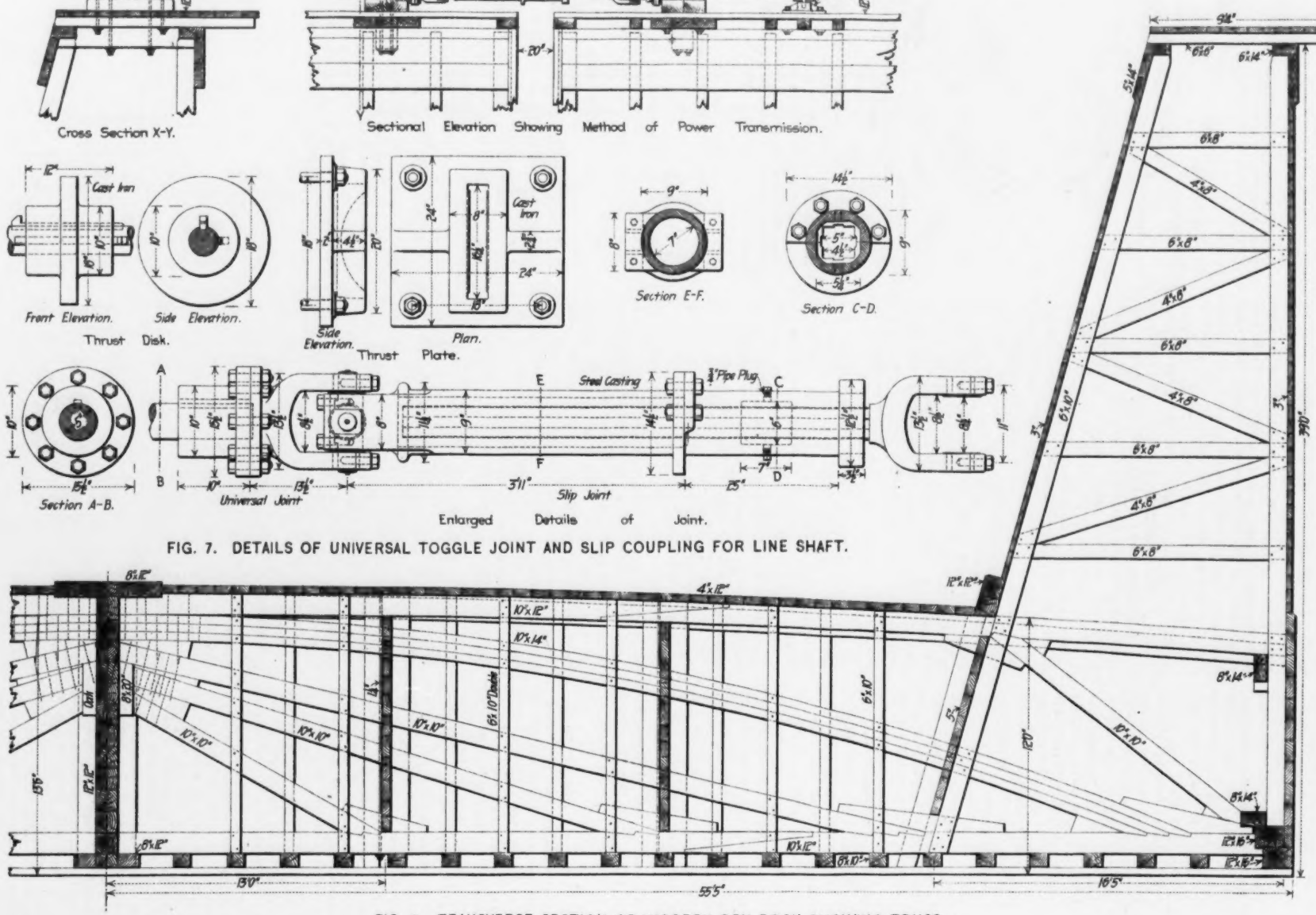
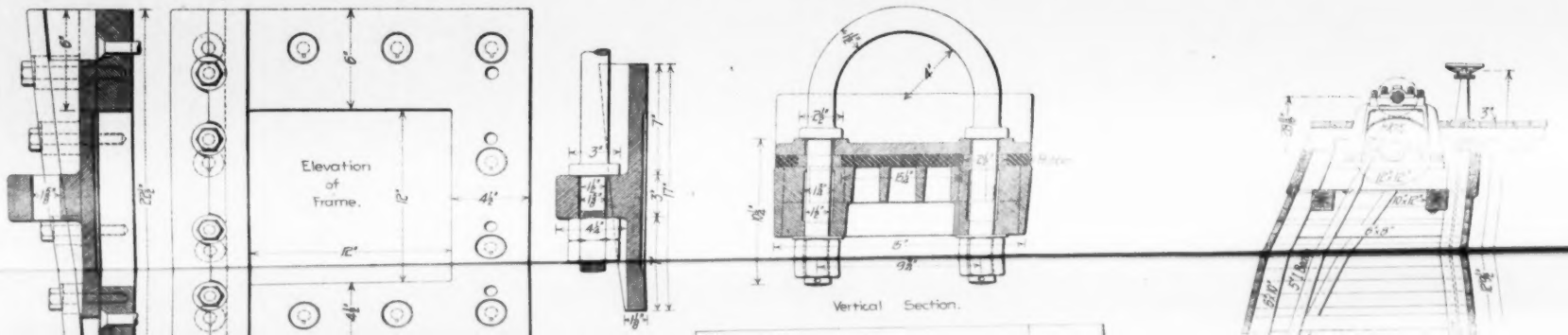


FIG. 2. TRANSVERSE SECTION OF WOODEN DRY-DOCK SHOWING TRUSS.



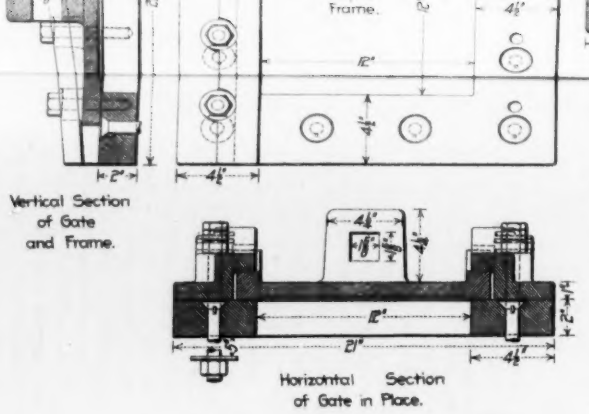


FIG. 8. DETAILS OF FLOOD GATE.

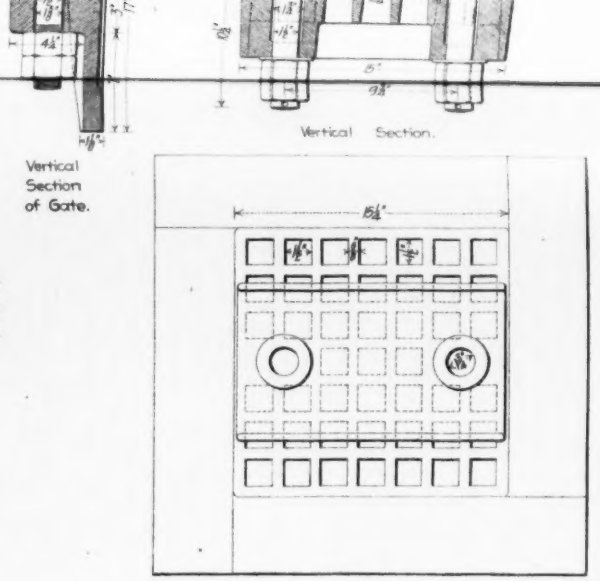


FIG. 4.
FOOT VALVE
OF PUMP.

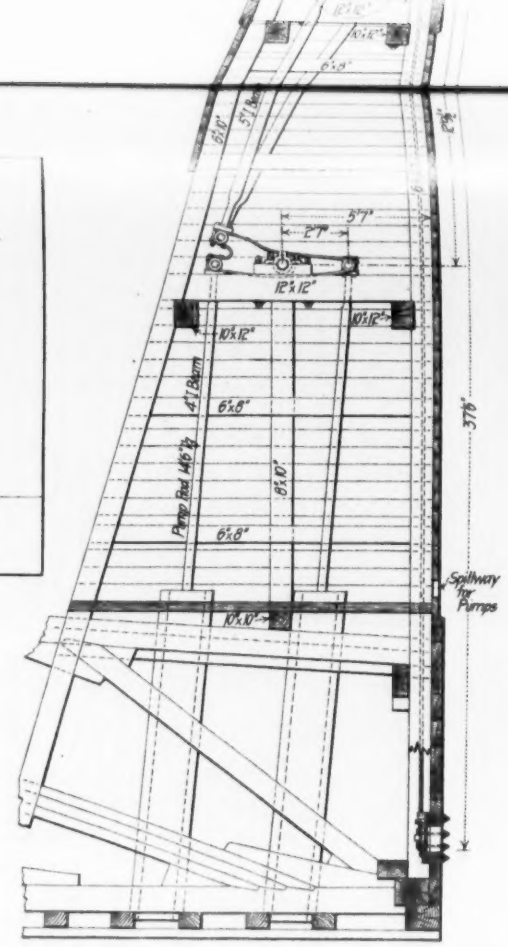


FIG. 3. TRANSVERSE SECTION OF ONE WING,
SHOWING PUMPING ARRANGEMENT.

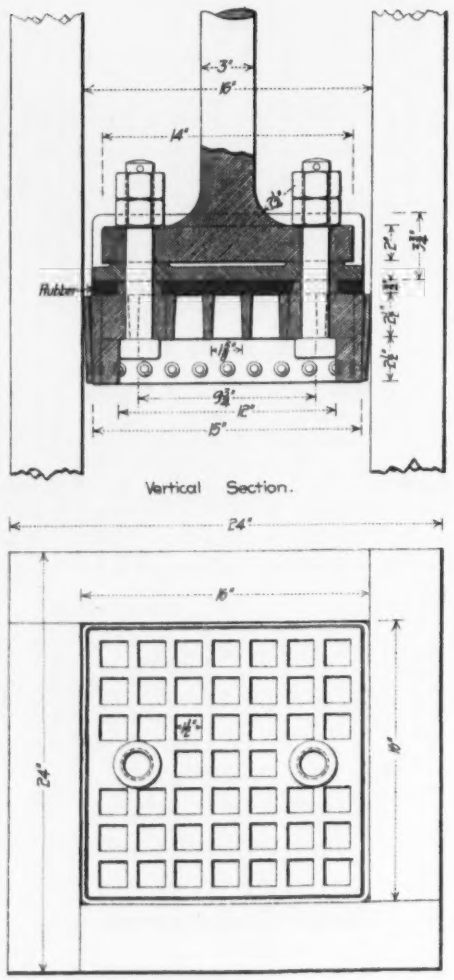


FIG. 5. DETAILS OF FOOT VALVE
AND PLUNGER OF PUMP.

10,000 TON SECTIONAL

WOODEN DRY-DOCK.

Built by the

Tietjen & Lang Co.,

Hoboken, N. J.

Faber du Faur & Donnelly,

132 Nassau St.,

New York City,

Engineers.

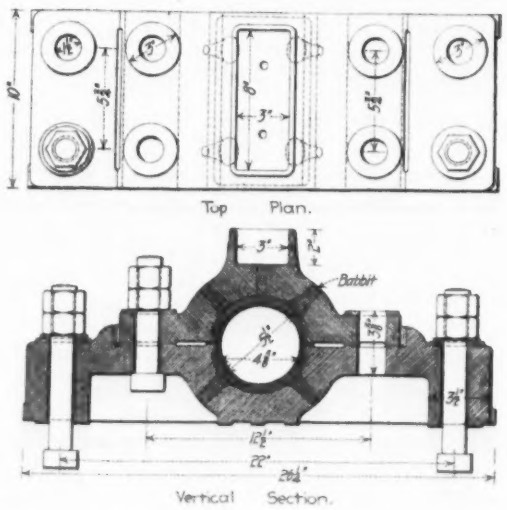


FIG. 6. PILLOW BLOCK FOR LINE SHAFT AND COUNTER SHAFT.

CHAS. HART, LITH., 86 VESEY ST., N. Y.

depreciation. There is no indebtedness against any of the plants. They stand a clear available asset to the city; and if figured on the basis of private plants they are worth a great deal more money than the inventory shows, for the reason that, owing to their ownership by the city, we saved last year a total of $192,891 over what rented lights would have cost. Their value to the city, therefore, if figured on this basis, would be very high. There is no reason why they could not be sold to any private company on at least a 10 per cent. earning capacity, which would make them worth as an investment $1,928,910.

State highway improvement in Connecticut has been far more widely distributed than in any of the other states taking a direct part in road construction. The last report of Mr. Jas. H. Macdonald, of Hartford, State Highway Commissioner of Connecticut, shows that 159 of the 168 towns in the State have received State aid since the movement was inaugurated in 1895. Moreover, 153 of the 169 towns applied for a portion of the $350,000 appropriated for the two years 1899 and 1900, showing a continued and increasing interest in the work. One reason for the wide distribution of the State aid is that it is available for the improvement of dirt roads, by grading, as well as for the construction of telford, macadam, or gravel roads. Another reason is that the new law of 1899 requires small towns to pay only one-fourth the cost of the improvements, instead of the one-third demanded of the larger towns. During the six years for which appropriations have been available, broken stone or stone and gravel has been put down on 317 stretches of road, gravel on 66, while grading alone has been done on 91, and grading in connection with some of the roads permanently improved has been done in 32 instances. It is interesting to note that the law of 1895 divided the expense of the State roads equally between the State, counties, and towns; the law of 1897, between State and towns equally, while that of 1899 puts one-fourth of the cost on the smaller and two-thirds on the larger towns.

IS THE SMELTING OF IRON ORE BY ELECTRICITY PRACTICABLE?

It has long been elementary knowledge that the economical production of iron depends as much on fuel supply as on ore supply. Pittsburg's preeminence as a center of iron production is due primarily to her proximity to the best of coking coals. The Birmingham district in Alabama was recognized as a permanent center of the iron industry as soon as the value of its ore deposits and its coal deposits closely adjacent was proven.

At many places in the world great deposits of rich iron ore occur; but a large proportion of them are of little value for lack either of coal near at hand or of transportation facilities to take the product to the coal.

It is a noticeable fact that where transportation takes place in assembling the raw materials for pig iron production, it is the iron ore which goes to the coal and not, save in exceptional cases, the coal which is carried to the ore. The Lake Superior ore, for example, goes to meet the fuel for its smelting in the Pittsburg district. The Cuban ore is brought to the United States. The Newfoundland ore is carried to the coal of Nova Scotia. The Spanish and Algerian and Swedish iron ores are carried to the furnaces of England and Germany. The ore is, indeed, heavier than the fuel required for its reduction; but it stands carriage much better, is less bulky, and, more important than either, it is of advantage to have the resultant product as near as possible to its final market.

Nevertheless, the countries which possess iron ore but no fuel are naturally discontented that the prosperous industry built up by their raw material should chiefly benefit other countries or sections. All economists, whether free traders or protectionists, agree that it is more advantageous for a country to export manufactured goods than raw materials. Had Spain been able to turn her stores of iron ore into finished products before exporting them, she might now be one of the richest of European countries.

A recent editorial in the New York "Journal of Commerce" discussed the relations of the State of Minnesota to the new United States Steel Corporation and pointed out the well-known fact that the states in which the enormous deposits of Lake Superior iron ore occur are anxious to see blast furnaces and rolling mills established within their borders to work up the iron ore that is now sent to furnaces in Illinois and Ohio and Pennsylvania. Concerning this matter the "Journal of Commerce" said:

> So long as coal and coke are the agencies employed in smelting the ore, it is quite unlikely that the iron and steel industry will have its seat near the Minnesota iron mines. On the other hand, in the not improbable event of the problem of smelting without fuel being solved by electricity, there might be a sudden transfer of the furnaces to the point nearest the mines which was in possession of a great water power. In the county of St. Louis, where most of the Minnesota mines are situated, there is a practically inexhaustible supply of water power capable of easy conversion into electricity. When this can be utilized so as to wipe out the thousand miles which separates the ore from the coal, a revolution in iron and steel production will have been effected from which Minnesota may rightfully expect to profit.
>
> But such a revolution would by no means contribute to the prosperity of the United States Steel Corporation. The value of its stock would suffer a very serious shrinkage if the manufacturing plants which it owns at Pittsburg, Lorain and Chicago were to become antiquated by the elimination of coal from the processes of metallurgy. In the way of such a change in the application of calorific energy the simplest dictates of self-preservation would compel the United States Steel Corporation to place all possible obstacles.

Our contemporary does not at all exaggerate the profound economic effects which the discovery of a commercially successful method of electric iron smelting might produce. If water power, by the aid of electricity, could replace the coal mine in iron ore reduction, Spain and Norway might become the iron and steel centers of Europe, Duluth and Sault Ste. Marie and Niagara would eclipse Pittsburg and Cleveland as centers for iron smelting and new centers of economic production would doubtless spring up of which nothing is now known.

Now, it is a very simple matter to determine whether such a thing is possible; and inasmuch as speculations of this sort are frequently brought forward, it has seemed worth while to present here the solution of the problem. We will try to make it so elementary that even the non-technical reader may understand the method and be able to appreciate the correctness of the solution.

In the first place, iron ore is now reduced to a metallic state in the blast furnace or "high furnace," as the Germans call it; a huge cylinder set on end, into the top of which ore and fuel and flux are dumped, while air is forced in near the base by blowing engines. A modern blast furnace requires about a ton of coke per ton of pig iron produced, the quantity varying, of course, with the efficiency of the furnace plant, the composition of the ore, and many other factors. Of all the heat generated by the combustion of the coke, about one-quarter is expended in reducing the iron ore from the form of an oxide to a metallic state. It must be understood that the union of oxygen with iron produces heat, just as does the union of oxygen with coal or with hydrogen gas; and the heat produced is a fixed and definite quantity for a given weight of iron. When the iron and the oxygen are forced apart, heat is absorbed and just the same amount of heat that was liberated by their union. The heat required to reduce a pound of metallic iron from its ore amounts to 3,396 heat units.

So far as this portion of the heat consumed by the blast furnace is concerned, it is certain that nothing can replace it save a similar quantity of heat or an equivalent quantity of energy in some other form. If it were possible to tear the oxygen from the iron by the direct action of the electric current, without the production of heat at all, just as much energy must be expended as when heat is used for the separation. In other words, a certain quantity of work must be done upon a pound of iron oxide to separate the oxygen from the iron, and it makes no difference whether we measure this work in foot-pounds, in heat units or in watt-hours of electric current. If this is clearly understood, the rest is easy.

Suppose, now, that by some at present unknown process, it should be made possible to reduce iron from its ores by the direct action of electricity, and without the intervention of heat. Let us assume, further, that this process is very near to theoretical perfection; that is, that nearly the whole energy of the applied current is devoted to separating the metal from the oxide. If it were indeed perfect and could have perfectly pure ore alone to work on, then the energy required would be (as stated above) equivalent to 3,396 h. u. per lb. of metal. All ores contain impurities, however, which require additional energy for their elimination. It is fair to assume, therefore, that even the most perfect electric process imaginable could hardly use less energy than 4,000 h. u. per lb. of metal produced. We have then 4,000 h. u. $\times 2{,}000 = 8{,}000{,}000$ h. u. as the energy which our hypothetical electric process must produce to make a ton of pig iron. Let us next compute how much mechanical power will be required to produce this amount of energy:

One horse-power = 33,000 ft.-lbs. per minute, hence a horse-power day of 24 hours $= 33{,}000 \times 60 \times 24 = 47{,}520{,}000$. The "mechanical equivalent" of heat is 778. That is to say, if it were possible by machinery of theoretical perfection to transform the entire work of a horse-power acting for a day into heat without loss, we should have $47{,}520{,}000 \div 778 = 61{,}080$ heat units. Dividing now 8,000,000 by 61,080 we have 131. That is to say, our supposed electrical process will require one horse-power of energy acting continuously for 131 days to produce a ton of iron. In a year, therefore, of continuous day and night working a horse-power could produce 2¾ tons of iron.

Coming down now to commercial comparisons, the coke required to make 2¾ tons of iron in the blast furnace is worth at present market prices about $5.50. A 24-hour horse-power of electrical current for a year is worth anywhere from $20 upward. The conclusion is, therefore, that even if a process of electrical iron smelting could be developed, operating with nearly theoretical perfection, it would be only a laboratory curiosity, since its cost of operation under the most favorable circumstances would be several times as great as the cost of the present method of reduction of iron by the combustion of fuel in the blast furnace.

LETTERS TO THE EDITOR.

Another Definition for "Plunging a Grade."

Sir: Referring to J. O. E.'s query in your issue of April 18, a plunging rod is a light steel rod generally about ⅜-in. diameter with a sharp point. The operation of "plunging a grade" is driving or plunging the rod into railway embankments to ascertain whether the close-cutting and grubbing has been properly done, and also whether logs, etc., have been removed or whether they have been covered up with the earth. Very truly yours,

T. Rhys Smith, Assoc. M. Inst. C. E.

150 Broadway, New York, April 24, 1901.

Mr. Ernest McCullough, of Lewiston, Idaho, sends us a definition of the term similar to that given by Mr. McNeal in our last issue. He says:

> I first heard the term used by an English engineer in 1889 in Southern California. I was mystified when told that it would expedite matters to "plunge the grade"; but when the matter was explained it was easy and I have found it to be a common practice where the lay of the ground permits. It is akin to the "boning rods" used in tile drainage work and to the ordinary sticks used by every Irish curb setter to fix curbing in place.

Improving Sandy Roads in Michigan.

Sir: I notice in your issue of April 18th the article by Prof. I. O. Baker on the care and construction of earth roads in Illinois, in which he says:

> The only thorough and permanent improvement possible for a sand road is to add a layer of tough clay and incorporate it with the sand.

It is different in Michigan. Some of the very best roads in the state have been made by putting gravel directly on the sand, using a gravel which has just enough clay in it to bind it together. It gives a good deal better result here than clay alone. Coal ashes also work remarkably well on the sand in this vicinity. Yours truly,

F. Hodgman.

Climax, Mich., April 22, 1901.

An Early Subaqueous Viaduct.

Sir: With reference to the article on this subject in your issue of March 28, it may interest you to know that about the year 1867 a railway, identically on the plan described, was partly constructed under the Thames from Waterloo Station. It was known as the Waterloo & Whitehall Ry., and operations were suspended in consequence of the financial crisis following the Overend & Gurney failure.

I am not sure just how far the work had progressed, but a good deal had been done to the foundations and some

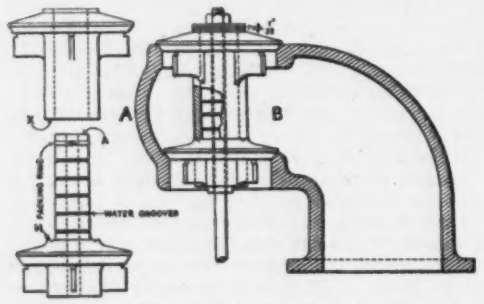
of the tubes were built at Millwall, one at least being launched and floated up the river to the site. The tubes were circular in section, covered with external rings of brick in cement secured to T-shaped cleats.

Yours faithfully, F. E. Robertson.

8 Great George St., London, Eng., April 16, 1901.

The "Compensating" Throttle Valve.

Sir: It was with considerable interest that I read your comments in the April 25 issue on the Chambers compensating throttle valve for locomotives, as the subject had been a somewhat puzzling one to me. Having had considerable practical experience with this troublesome factor in the average locomotive, it did not at first appear to me that Mr. Chambers' device was practical, since if made according to the specifications, it surely would be inoperative. But as there is every reason to believe that this valve is being used with success on locomotives, we must fit our theories to the actual facts.



An Alleged "Compensating" Throttle Valve for Locomotives.

In the face of the printed statements that there is 1-32-in. movement between the shoulders of the component parts of the valve when properly seated, I will say that it is my firm conviction that nothing of the kind is the case. While such an allowance may be roughly made when turning the valve, it is more than probable that when fitted and ground in place that the shoulders abut when the two parts of the valve are seated. The contention that a film of water could exist between the shoulders of the parts of the valve is absurd when the temperature of the throttle-box and the fact that the film of water would be practically at atmospheric pressure with the valve closed is considered.

We have no positive proof that the valve is more durable than the ordinary type beyond the assertion of the interested parties. Whether it would prove more durable under average conditions, can only be ascertained by actual trial under the supervision of impartial railway men. Personally, however, I am inclined to believe that this valve will be found less leaky in average practice for the following reason:

The distortion to which the throttle-box is inevitably subjected by the external pressure and the high temperature due to the steam pressure, would probably be not great as one would in a measure offset the other if we could consider the throttle-box as being symmetrical in shape with all vertical planes of bisection, as is the valve. The throttle-box, however is not of symmetrical shape, and while it may be internally braced to resist compressive stress, the effect of the higher temperature must manifestly be unequal at A and B when the valve is closed. The result is that the two seats are tilted slightly so that they are no longer in parallel planes, as when ground. The Chambers' throttle, by reason of the slight play existing between the component parts, probably "compensates" for this inequality, and nothing else.

Fred. E. Rogers.

East Orange, N. J., 232 Sanford St.

Why Does an Earth Road Break Up When the Frost Comes Out of the Ground?

Sir: Recently, in reading a pamphlet on road construction, I came across the following theory of the saturation of the soil in a roadbed when the frost comes out of the ground in the spring:

The explanation is that after the ground freezes, water rises slowly in the soil by hydrostatic pressure of the water in higher places; and if it is not drawn off by underdrainage it saturates the subsoil and rises as the frost goes out, so that ground which was comparatively dry when it froze is practically saturated when it thaws.

In other words, the frost seals all surface outlets so that subsurface flow of water below the frost line takes place toward the low spots. This, I believe, is the commonly accepted theory, but I find it difficult to reconcile the theory with several facts, the first of these being that even at the summit of a hill and where the road does not lie in a cut it will frequently cut up as badly as in lower places. Second, even where subdrainage is perfect, an earth road will cut up in the spring. Third, a road running along the north side of a valley which lies east and west cuts up less than a road on the south side. Fourth, a road swept by wind, or cleaned by a snow plow, cuts up far less than one where the snow is left till it melts. Conceding these statements, anyone will quickly formulate the true theory of the softening of a roadbed in the spring. Saturation of a road is not due to subsurface flow caused by hydrostatic pressure, for even where the whole country is a dead level, saturation occurs and is often the worst; but saturation is due to the damming of ditches and of the roadway by the snow and slush that effectually prevents the water from escaping. The deeper the snow and the slower its melting, the greater the saturation of the roadbed. On summits not swept clean by winds, in cuts, on the shady side of valleys and in shady places generally, in forests and wherever snow lodges and stays long, there will the soil be saturated and there will be the most difficult part of a road to maintain.

It follows as a corollary that any means, whether natural or artificial, that effects a speedy removal of snow in the spring will preserve the road from cutting up. One method that I have used to advantage is the spreading of fine charcoal over the snow on the roadway in the early spring. It is surprising to see how fast the black coal "eats" its way into the snow on a sunny day. A method involving more labor but well worth the expense on bad stretches of road is the use of a snow-plow for pushing the snow off the traveled way and providing a gutter for the melted snow to run in. The theory as to the cause of the softening of a roadbed in spring is important, since it leads to certain valuable conclusions as to road location and road maintenance. Yours truly,

Halbert Powers Gillette.

Rochester, N. Y., April 25, 1901.

Wet or Dry Concrete Work—Which?

Sir: The abstract of the paper read before the Western Society of Engineers, entitled "An Experiment with Wet and Dry Concrete," by Mr. Irving Hitz, is noted in the Engineering News of March 28, 1901. I would like to add the testimony of actual experience in support of the truthfulness of the result of Mr. Hitz's experiment.

Early in the year 1899, I was called upon to take charge of the construction of outlet-gates and conduits, for the purpose of drawing off 25 ft. in depth of the waters of the Twin Lakes in Colorado, in pursuance of a plan to convert these lakes into a storage reservoir for the storage of water for use in irrigating agricultural lands in the valley of the Arkansas River at a point some distance east of the city of Pueblo. When I took charge of the work, the foundation was practically finished. It consisted of piling driven 16 ft. in depth and about 4 ft. c. to c. each way, supporting a concrete monolith 5 × 72 × 75 ft. containing two sets of 4-in. steel I-beam grillage spaced 2 ft. c. to c. The concrete in this foundation had been laid by contract, under the direction of an inspector in the employ of the company, according to the accepted theory for the production of the best quality of concrete, i. e., as dry a mixture as could be handled and rammed into place.

After making a careful examination and study of this work I found that when broken it showed many voids and pores along the lines of fracture and that the broken stone, contained in the mass, in almost every instance pulled bodily out of the mortar; and after making several experiments with wet and dry concrete, I decided that during the execution of the balance of the work I would use a concrete mixture containing a decided excess of water.

We built four arched conduits, as shown by the accompanying cuts. The concrete was composed of 1 part Utah Portland cement, 2 parts clean sharp quartz sand, and 4 parts broken granite, sized to pass through a 2-in. ring. A Ransome concrete mixer was used. A section 16 ft. in length of two tunnels was constructed at one time, the run necessary to fill the forms was made continuous and lasted about nine hours. Forms were left in place about three to four days, and then moved longitudinally to the next 16 ft. section. New work was joined to old by the usual method of roughing the surface of the old work, as by nailing blocks and strips on the face of the forms so as to leave irregularities and depressions in the face of the work to which other work was to be joined. The entire area of the work was thus covered in six settings of the forms. The mixture was made so wet that the ramming done was almost nil, and yet the resulting concrete when thoroughly set, was very nearly as solid as a good close-grained granite, and when broken almost all fragments of stone in the mass would be fractured on the line of cleavage, and would show no appreciable pores or voids on the broken surface.

This work has now stood the test of about 18 months time and passed through two severe winters at an altitude of 9,200 ft., and does not show a crack or scale of any kind. No cracks have shown themselves even at the points where forms were joined together, the material in one being set hard before the other form was set up and filled, this would indicate that there has been but little if any, shrinkage in the work. The fact that there is no crack on the line of the joints is shown very conclusively by the enclosed photographs of the down-stream face of the conduits; there was a joining of two forms made on a vertical line through the center of the center pier. There is not a crack or other imperfection on this entire exposed face.

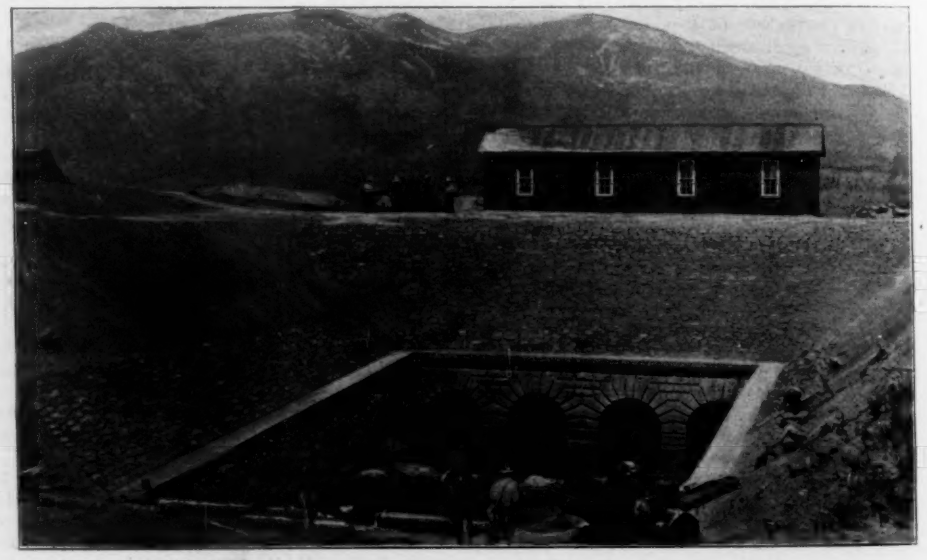
From my experience with this work I am fully convinced that a mixture containing an excess of water, theoretically, is to be the concrete of the future, rather than one mixed according to the present laboratory formula.

Very truly yours, O. O. McReynolds,

Assoc. M. Am. Soc. C. E.,

Chief Engineer Twin Lakes Land & Water Co.

Nepesta, Colo., April 9, 1901.



OUTLET TUNNELS OF TWIN LAKES RESERVOIR; DOWN STREAM PORTALS.

A Simple Gage for Use With the Venturi Meter.

Sir: In connection with the gage for use with the Venturi meter, described by Mr. Charles P. Paulding in Engineering News of Feb. 28, the question suggests itself: Of what advantage is the U-tube? If this be omitted, the two outer tubes (B, B in Mr. Paulding's Fig. 3) being connected at the top and containing air under pressure above the water, the difference between the heights of these two columns of water gives at once the required pressure-difference. Two readings are thus required instead of four.

Such a form of gage would doubtless be useful, not only with the Venturi meter, but in other cases in which it is desired to measure small pressure-differences, but not absolute values of the pressures. If the instrument is to be used under great pressures, however, it will be necessary to provide some means (as an air pump) for maintaining the requisite volume of air in the bent tube.

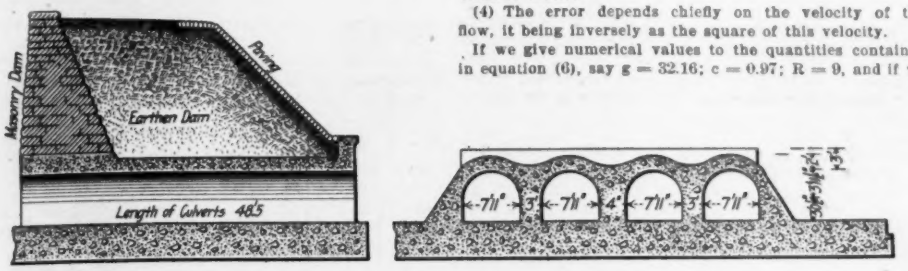
The advantage of this gage over the well-known mercury U-tube would, of course, be its greater sensitiveness. If the pressure is subject to rapid (though small) oscillations, as is often the case in practice, this advantage will be partly neutralized by the increased difficulty of taking the two readings simultaneously and with precision.

It should be noticed, also, that in strictness the reading requires correction for the weight of the air column. This correction is unimportant when the pressure is small, but may be appreciable under such high pressures as often exist in pipe lines in mountainous regions. It amounts to 1% for a pressure a little less than eight atmospheres, or about 260 ft. head.

L. M. Hoskins.

Stanford University, Cal., March 13, 1901.

Sir: Mr. Wm. Cain, Professor of Mathematics at the University of North Carolina, has called my attention to an error in the algebraical equation for the reading of the gage for a Venturi meter, in my article in your issue of Feb. 28. On looking it over I see that the last few lines



Longitudinal Section. Cross Section of Tunnels.

SECTIONS OF CONCRETE OUTLET TUNNELS, TWIN LAKES RESERVOIR.

at the foot of column 2, page 148, should read as follows:

Algebraically we have:

$$\text{Head at point marked } P_a = P_a - h_g;$$
$$\text{Head at point marked } P_b = P_t - h_t,$$

and the reading of the inner gage = $P_b - P_a$ = head at P_a — head at P_b; therefore

$$P_b - P_a = P_g - h_g - P_t + h_t,$$

and

$$P_a - P_t = (P_b - P_a) + h_g - h_t),$$

instead of equalling

$$(P_a - P_b) + (h_g - h_t),$$

as I had it. This error affects no other part of the description.

Very truly yours,

Charles P. Paulding.

000 River St., Hoboken, N.J., Mar. 19, 1901.

The Flow of Water Through Venturi Meters.

Sir: I have read in Engineering News of Feb. 28, 1901, an article by Mr. Charles P. Paulding under the title "An Inexpensive Gage for Use with the Venturi Meter." In connection with this subject I send you a note, which I hope you will find of some use.

The formula given by Merriman for finding the actual discharge with the Venturi meter is the following:

$$q = c \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \sqrt{2g (H_1 - H_2)}. \quad (1)$$

Where q is the volume of water per second, a_1 is the area of the large pipe, a_2 the area of the reduced pipe, H_1 and H_2 are the columns of water which act on the centers of sections a_1 and a_2, g represents the acceleration of gravity, and c is a coefficient, the numerical value of which may change with different causes, depending on the conditions of the meter and on the volume of the flow. In a series of 55 experiments quoted by Merriman this value oscillated between 0.94 and 1.04. The exact knowledge of the true coefficient that must be employed in every particular case is a very important thing. The measuring of the two heads of water acting on the two sections of the meter does not need a close approximation in the cases in which the velocity of the water is greater than 1 ft. per sec., as is easily demonstrated.

Let us again consider equation (1), which may be transformed into the following:

$$q^2 = \frac{c^2 a_1^2 a_2^2}{a_1^2 - a_2^2} 2g (H_1 - H_2). \quad (2)$$

If we substitute for a_2 its equivalent $\frac{1}{R} a_1$, (R) being the ratio between the two areas, and if we call $H_1 - H_2 = \triangle$ the last equation will become

$$q^2 = \frac{c^2}{R^2 - 1} a_1^2 \times 2g \triangle. \quad (3)$$

If there is a small difference or error in the appreciation of $\triangle$ (which we will call $d \triangle$), there will be a corresponding error, d q, in the volume of the water. These two errors are obtained by differentiating equation (3).

$$2q\, dq = \frac{2g c^2 a_1^2}{R^2 - 1} d \triangle. \quad (4)$$

We can also establish the following:

$$q^2 = a_1^2 v^2, \quad (5)$$

where v is the velocity of the flow.

Dividing the two members of equation (4) into the two members of equtation (5), we find:

$$\frac{dq}{q} = \frac{g c^2}{R^2 - 1} \frac{d \triangle}{v^2}. \quad (6)$$

The first member represents the percentage of the error in the metering; or in other words it is a measure of the degree of approximation with which the volume of water may be ascertained by the Venturi meter. As may be readily seen, this percentage depends on the following:

(1) On the ratio (R) of the two areas. The greater this ratio is the better.

(2) On the value of $d \triangle$, or in other words, on the accuracy with which readings are taken on the gage.

(3) The error does not depend on the volume of water, and it is entirely independent of the diameter of the pipe, which is a very important and valuable feature of the Venturi meter.

(4) The error depends chiefly on the velocity of the flow, it being inversely as the square of this velocity.

If we give numerical values to the quantities contained in equation (6), say g = 32.16; c = 0.97; R = 9, and if we divide the last member of equation (6) into 12, so as to have $d \triangle$ represent inches, we get:

$$\frac{dq}{q} = 0.03152 \frac{d \triangle}{v^2}. \quad (7)$$

Now, if we desire the error in the volume of wafer not to exceed $\frac{1}{100}$; or in other words $\frac{dq}{q} = 0.01$, we finally obtain:

$$d \triangle = 0.284 v^2.$$

This formula gives the numerical values of $d \triangle$ in terms of the velocity of the flow, and it may be readily established that when this velocity is 1 ft. per sec., $d \triangle$ is a little more than ¼-in. If the velocity is 2 ft., $d \triangle$ = 1.14 ins.; and if the rates of flow are greater, $d \triangle$ increases very rapidly.

With the use of the gage devised by Capt. Metcalfe, there will be four readings, and it is possible that these four readings are affected by small errors which may become cumulative. In this case it will be necessary to divide the value of $d \triangle$ by 4 to obtain the degree of approximation with which the scales must be read in order that the error in the metering shall not exceed 1%. For instance, in case the velocity should be 1 ft. per sec. the accuracy with which the scales must be read need not exceed 1-16-in. In the case of a velocity of 12 ft. per min., as mentioned in the article by Mr. Paulding, the errors in the readings should not be greater than 0.0025-in., in order to obtain a meter reading which is correct within 1%, and this is quite impossible.

When the Venturi meter is employed for the measurement of water flowing with such low velocities, the ratio between the two areas of the meter should be made as large as possible. If this ratio were 13 instead of 9, the meter would be more than twice as accurate. Even in this case, however, I think a meter record correct within 4% would be as good as could be expected with a velocity of 12 ft. per min., as in the case quoted above.

On the other hand, it is well to remember that if the coefficient c in formula (1) is not exactly known in the particular case in which it should be applied, it would be useless to look for any great accuracy in the readings of the gage.

Manuel Marroquin y Rivera,
Professor of Hydraulic Engineering in the "National Engineering School" of Mexico.
214 Calle Sur 38, City of Mexico, March 8, 1901.

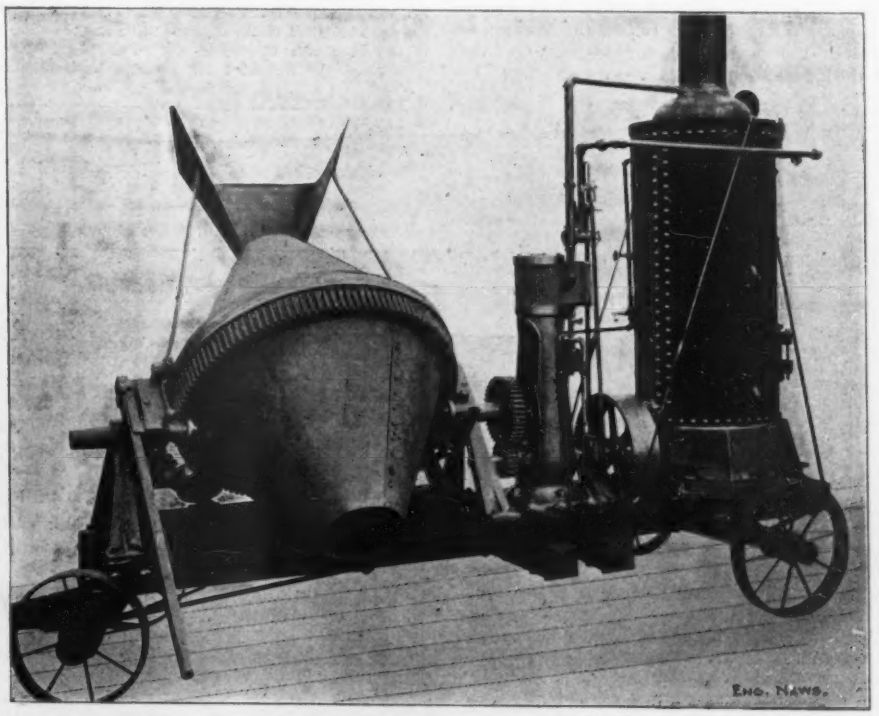
A NEW FORM OF ROTARY CONCRETE MIXER.

We illustrate in the accompanying cut a general view of a portable power concrete mixer, which is being manufactured by Mr. T. L. Smith, 134 Tenth St., Milwaukee, Wis. The same type of mixer is also built in stationary form and of various sizes. In all of these machines the notable feature is the tilting of the mixer drum to empty it. Other advantages claimed for the construction are described as follows in a letter to us from the builder:

As shown, the drum has the tapering ends necessary to a perfect discharge when tilted. The drum being small in average diameter and long, the lifting radius of the load is short and minimum power is required for driving. The conical steel ends of drum being naturally very stiff, heavy metal is unnecessary. These are riveted to a central annulus which has all the driving and guiding surfaces on its periphery. This annulus is a single casting, in the middle of the drum, which location is as far as possible from dirt. The wearing parts are therefore naturally protected.

Riveted to the shell of the drum on the inside there are four sets of rigid deflecting plates, one blade of each set being in the middle. Each set forms an approximate spiral, two sets being right hand and extending to the right hand of the middle, and two sets being left hand and extending to the left. The individual blades of a set are flat, and their stepped arrangement permits free discharge. The revolution of the drum causes each set to pass the material it picks up from the end towards and past the middle, causing an alternating endwise movement of the material while rolling it over, thus effecting a rapid mixing. This action of the blades also materially increases the capacity of the drum, enabling a larger charge to be fed in than would otherwise be possible.

The drum is mounted on rollers supported by a steel frame swung on trunnions. Two flanged rollers underneath the drum carry the weight, and four small rollers bearing against the edges of the annulus, keep the drum in position. The tilting axis, or center line of the trunnions is located approximately at the center of gravity of the load in the drum, below the drum axis. This makes the empty drum slightly top heavy, and counterweights are placed in a suitable pan attached to the frame to neutralize this. The drum is then always practically balanced, empty or full, and is therefore easily tilted.



VIEW OF PORTABLE ROTARY CONCRETE MIXER OPERATED BY STEAM POWER.
T. L. Smith, Milwaukee, Wis., Builder.

Power is transmitted to the drum through one of the trunnions, which is thus made a shaft bearing. A cross-shaft and intermediate bevel and spear gears provide positive driving, which is not affected by tilting the drum. Tilting can, therefore, be done while running at full speed.

The features above mentioned all combine to assist in cleaning the drum by washing while the drum is in motion. When properly and regularly washed, the surfaces inside the drum become polished without sensible wear, and are easily kept bright. The illustration shows the portable steam machine in the discharging position. This machine is also furnished equipped with a gasoline engine, the engine and accessories being housed in as a protection from dust and weather.

A DOUBLE CABLEWAY FOR THE NEW YORK RAPID TRANSIT RAILWAY WORK.

We illustrate in the accompanying cuts one of two cableway plants erected for J. C. Rodgers & Son, and now at work on the rapid transit underground railway at 120th St. and 127th St., on Lenox Ave., in New York city. On this portion of the rapid transit railway work the contractors named above are carrying out the construction by first excavating parallel trenches for the side walls and then removing the center core and erecting the floor and roof lining. The cableways are being used in this work to handle the excavated material and also the materials for construction. Their chief novelty is that they are double cableways. The towers are built like ordinary cableway towers throughout, except that they are made wide enough to carry two parallel cables spaced 12½ ft. apart, each of which can be operated independently of the other. Fig. 1 shows the framing of the head tower, and the general arrangement of the cables and the engines and connections for operating them. Fig. 2 is a general view of one of the plants in operation.

The towers are 35 ft. high, and are mounted on wheels to permit the transportation of the cableway from one section to another. They are spaced 370 ft. apart, and the main cables are carried over their tops and anchored to piles or deadmen driven into the ground at the rear of the towers. These cables are 1⅛ ins. in diameter and the hoisting cables, carriages, etc., are designed for a load of 3 tons each. The hoisting engines are carried on the platform of the head tower, as shown by Fig. 1, and are supplied with steam from two locomotive boilers set on the ground at the rear of the tower. Each cableway may be operated independently or the two may be operated in combination. At the time the plant was visited by a member of the editorial staff of this journal, the two cableways were being operated separately, removing the excavated earth. An elevated platform was employed having a hopper chute underneath which the teams drove, the cableway buckets dumping into the top of the hopper. According to the builders of the plants, each double cableway working both cables will excavate and convey between 150 and 200 loads in an 8-hour day. These cableways were erected by the Rawson & Morrison Manufacturing Co., Cambridgeport, Boston, Mass., and were designed by Mr. Gust. Pers. Wern the manager of their New York office. We are indebted to Mr. Wern for the information from which this description has been prepared.

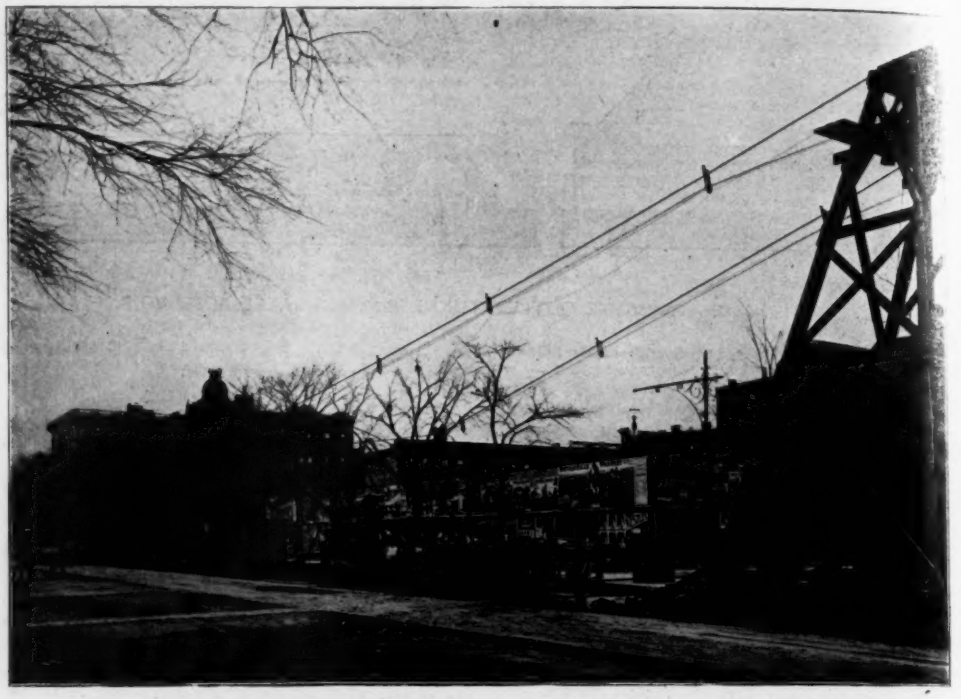
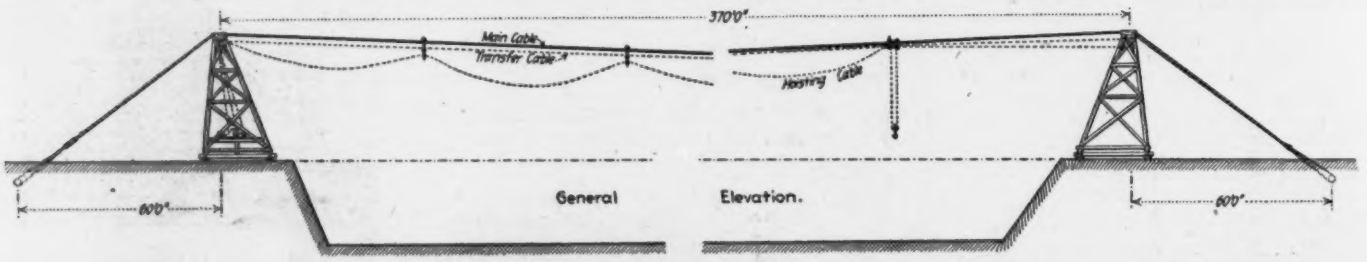
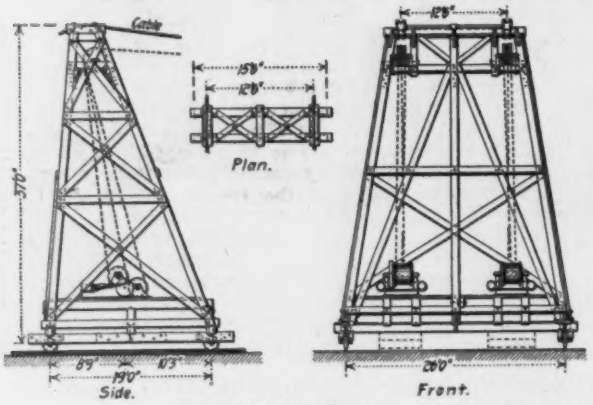


FIG. 2. GENERAL VIEW OF DOUBLE CABLEWAY AT WORK ON NEW YORK RAPID TRANSIT UNDERGROUND RAILWAY.
J. C. Rodgers & Son, New York, Contractors; Rawson & Morrison Mfg. Co., Boston, Builders.





Elevations of Tower.

FIG. 1. HEAD TOWER FOR DOUBLE CABLEWAY FOR NEW YORK RAPID TRANSIT UNDERGROUND RAILWAY WORK.

A PECULIAR HEATING AND VENTILATING SYSTEM has been installed in the Olympia Mills at Columbia, S. C., by W. B. Smith Whaley & Co. Two 14-ft. Sturtevant fans force the unheated air through horizontal underground ducts extending along both side walls. Branches from these ducts connect with vertical flues built in the side walls and deliver air to the various floors. Instead of the usual coil arrangement at the fan, Sturtevant standard corrguated sectional base coils are placed in the main ducts where the flues connect with them. This arrangement was used in order that the amount of heat supplied to any part of the mill building could be controlled without affecting the air supply. It also saves the loss of heat in the main ducts in the basement and permits the use of slightly smaller ducts on account of the lower temperature of the air. The B. F. Sturtevant Co., of Boston, Mass., furnished the apparatus for the system.

NARROW LONDON STREETS, says the "Times," are causing a congestion of traffic and loss of trade among the smaller shop keepers. The trouble arises from the fact that when street widening was considered some years ago in old London the authorities concluded that water and gas pipes and sewerage completed the list of underground street fixtures. They did not foresee the advent of conduits for telegraph and telephone wires and pneumatic dispatch service. The result is that some of the principal entrances to "the city" are almost continually blocked by the necessity for relaying old water and gas pipes or laying new electrical lines, and the traffic and trade suffer accordingly. The greatest complaint arises from a lack of system in carrying out this work. No sooner has one set of workmen completed the excavation for one purpose than another set dig up the street for some other purpose. The "Times" concludes that the only complete and effective remedy is a general system of subways, such as was proposed for the Strand some years ago. While such a scheme would cost millions, "it must be ultimately faced," says our contemporary.

AN EXPLOSION AND FIRE in an electro-chemical works at Griesheim, near Frankfort-on-the-Main, Germany, on April 25, resulted in the deaths of 80 or more persons and the destruction of nearly the whole town, including three chemical works.

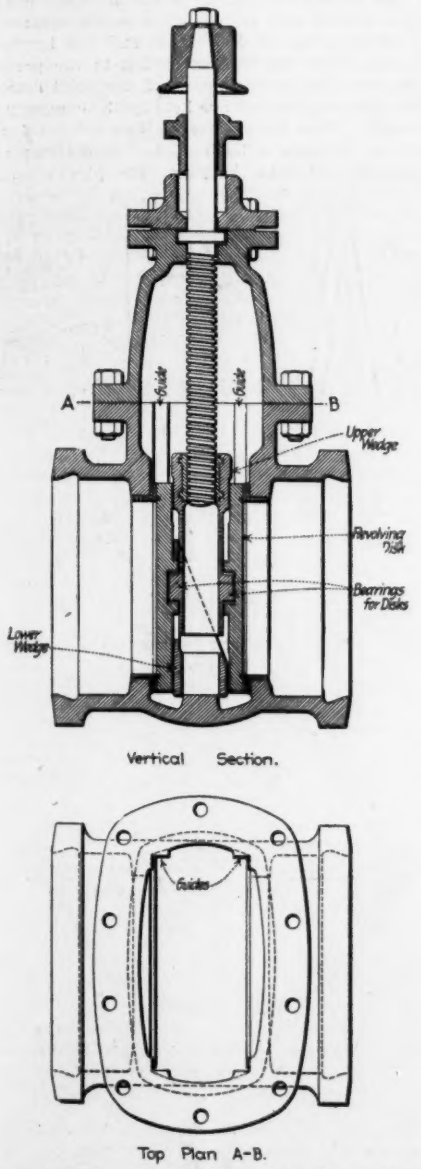
A VALVE WITH DOUBLE REVOLVING GATE DISKS.

A valve which combines double-revolving gate disks, compound equalizing wedges and parallel seats, is illustrated and described below. The makers claim that they have made several improvements, particularly in the compound wedges. The valve is made by the Darling Pump & Manufacturing Co., of Williamsport, Pa.

Fig. 1 shows the valve in sectional plan and in vertical cross-section. Fig. 2, reproduced from a

photograph, will aid greatly in understanding the design and action of the wedges and the revolving disks. The upper wedge has a threaded hole to receive the stem; also a bearing lug at each side on which the disks revolve loosely. The disks, in turn, are fitted with sockets on their inner surface to receive the bearing lugs. The lower wedge receives the upper one, and has a large hole in its main outer side to afford play room for the bearing lug of the upper wedge and the socket of the disk on that side. The two wedges have inclined faces, on each side, as indicated by the dotted line in the section, Fig. 1, and as is shown much more clearly in the view, Fig. 2. It is the action of these two inclined faces on each other that forces the disks home to their seats.

The disks roll on guides in the case, as shown by Fig. 1. It is urged that the rolling feature of



Vertical Section. Top Plan A-B.

Fig. 1. Details of 8-in. Gate Valve with Double Revolving Disks.
Made by The Darling Pump & Manufacturing Co.

the disks is especially advantageous in valves placed on their sides, obviating the necessity for rollers or other anti-friction devices in the case of very large valves.

The following description of the operation of the valve, together with some of the special claims made for it, was prepared by the manufacturers, at our request:

The valve being open, the parts hang loosely upon the upper wedge; the wedges are extended or are in alinement, and hence the gate disks are arranged with their outer faces at an interval less than the distance between the valve seats. The stem is turned and the parts descend free and clear of the seats until the lower wedge reaches the bottom of the case and its movement is checked; then the gate disks are in proper position, opposite the ports or pipe openings of the valve. The further downward movement of the upper wedge causes the inclined surfaces of the upper and lower wedges to slide upon each other and thus contract the wedge block longitudinally and spread it laterally. This brings the pressure to bear over almost the entire surface of the gate disks, instead of on one small point only, thereby forcing the gate disks firmly and squarely against the seats. This movement does not cause in any way the scraping of the gate disks across the seats or any undue wear upon either, so objectionable in some forms of valves.

It will be observed that the wedging to close the valve is from the top, which is an advantage, as it permits the top wedge to be withdrawn instantly in opening the valve.

When it is desired to open the valve and unseat the gate disks, the opposite movement of the steam causes the upper wedge to move longitudinally and independently of the lower wedge; also independently of the gate disks, by reason of the loose fit of the bearing lugs of the upper wedge in the bearing sockets of the gate disks. This movement of the upper wedge raise it instantly from the lower wedge (a quarter of a turn of the stem being sufficient to release), and reduces the lateral pressure upon the gate disks, without sliding them upon their seats, thus unseating the valve without frictional contact with the seats. The further movement of the stem raises the parts free and clear, leaving a straight passage through the valve.

The inclined coacting faces of the wedges are transversely beveled, and the lower wedge is wider than the body of the upper wedge, whereby lateral movement of the member is permitted. Thus in case of a slight irregularity of the valve seat (i. e., the seats not being perfectly parallel from any cause), a lateral movement of the gate disk is possible, insuring its proper seating.

As the valve is opened or closed, the contact of the peripheries of the gate disks with the guides in the case has the effect of partially turning the disks and thus presenting them in different positions to the seats, whereby the unequal wearing of either is avoided. The revolving motion of the gate disks, in either opening or closing the valve, will clear the seats of any obstruction or foreign substances which may have caught upon them.

The packing plate at the head of the valve stem is secured by four bolts, and may be removed without unscrewing a nut the full length of a long bolt up to the top of the gland follower. Instead of having the bolts project through the packing plate to the follower or gland, separate bolts hold the followers. These bolts have square heads, which fit into slotted places on the packing plate, and can be removed or inserted without disturbing the packing plate or the packing plate bolts. In an emergency any ordinary standard machine bolts can be used. The stuffing boxes and followers are of extra length and uniform in diameter to such an extent that but three sizes of packing are required to equip valves from 3 to 24 ins. in diameter.

These valves are at present made in sizes for pipe 2 to 16 ins. diameter; with either hub ends, spigot ends, screw ends or flange ends; either iron body bronze mounted, or all brass or all iron, and for test pressures of 300 to 2,200 lbs., depending upon the service required.

SCHEMES SUGGESTED BY THE EXPERT COMMISSION FOR THE IMPROVEMENT OF THE CHICAGO RIVER.

In our issue of April 4 we published a description of two plans proposed for the improvement of the Chicago River which was based on articles in the Chicago papers. This article, while in the main correct, erred in stating that the commission appointed to devise ways for increasing the flow of water to the drainage canal without injuring its navigability had "submitted its complete report and two plans." The commission has as yet made no report.

The facts of the case, as now furnished us from official sources, are briefly as follows: A few months ago, following the agitation over the difficulties of navigating large vessels in the river, an "Expert Commission" of five, three engineers and two attorneys, was appointed by the Trustees of the Sanitary District of Chicago. At the same time the Trustees also appointed a commission of 13 consulting associates, representing various public interests, making a complete commission of 18 members to consider the whole subject of the relation of the river to the city's commerce and the drainage canal, and to devise ways of improving and enlarging the river to give increased capacity of flow to the canal and better facilities for navigation. The Expert Commission of five members is composed of Hon. O. N. Carter (Chairman), John P. Wilson, Lyman E. Cooley, Ambrose V. Powell and Louis P. Friestedt, with Hiero B. Herr as Secretary.

This expert commission is to prepare information relative to certain schemes for effecting the desired improvements, and after due consideration will submit them to the general commission, with estimates of cost. These will then be considered by the commission, and one or more of the schemes will probably be selected for further elaboration by the expert commission. Up to the present time, three general projects have been worked out by the committee, the first of which is supplemented by two auxiliary schemes for the improvement of the North Branch and the Calumet district respectively.

SCHEME NO. 1.

The "Summary of Work Done," given in the article above referred to (Eng. News, April 4), is taken from the introductory remarks to the expert commission's presentation of Scheme No. 1, but in the table on p. 246 (1st column) the "Obligations for work done" should be $1,757,685. The "Proposed New Work," described in the same article, refers only to this one scheme, with its alternatives of a radical improvement of the entire river, or a moderate improvement in conjunction with a new connection with the lake on the line of 16th St.

Scheme No. 1 has two auxiliary or supplemental schemes, as already noted, which are known as

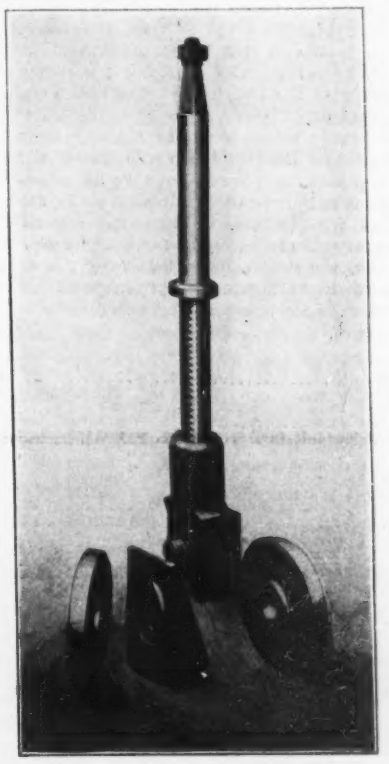


Fig. 2. Revolving Disks and Compound Wedges for Gate Valve.

Part 2 and Part 3, and may be briefly considered here. Part 2 relates to the proposed Calumet sanitary district, with an area of 94.5 sq. miles in Illinois and 47.5 sq. miles in Indiana. The total area would be 142 sq. miles, with a population of 118,357. A canal would be built either as an extension of the Illinois & Michigan Canal from Sag Station to the Little Calumet at Blue Island (estimated cost, $3,900,054); or a northern route from Summit southeast to the Calumet Harbor, near 114th St. (estimated cost $6,666,460). The canal would be operated by pumping works with a capacity of 60,000 cu. ft. per minute. Part 3 relates to the proposed North Shore sanitary district, with an area of 95.2 sq. miles, and a population of 47,469. A canal would be cut from a point on the lake shore near Wilmette, Ill., to the north branch of the Chicago River at Lawrence Ave., in Bowmanville. The canal would be operated by a pumping plant similar to that of the Calumet district. The estimated cost is $2,428,333, including canal, pumping works, right of way and bridges. Annual charge for operating the pumping works, $26,137; or $653,427 capitalized at 4%.

The estimates of total cost for Scheme No. 1

complete (which were not given in our former article) are as follows:

	Radical Improvem't.	Moderate Improvem't.
Chicago River and main channel.	$22,862,879	.....
Chicago River inlet and main channel	.....	$12,701,755
39th St. conduit.....	2,660,135	2,660,135
Calumet Northern canal.....	4,666,460	4,666,460
Lawrence Ave. sewer outfall....	1,328,822	1,328,822
North Shore canal.....	3,081,760	3,081,760
Total	$34,600,056	$24,438,932

SCHEME NO. 2.

This treats the Chicago and Calumet problems as a joint proposition, the North Shore treatment standing as in Scheme 1. It contemplates a "moderate improvement" of the Chicago River (as in Part 1 of Scheme No. 1) and the passing of such water therein as may not unduly injure navigation, with an auxiliary supply by the 39th St. conduit. All additional water required for the main channel is to be supplied through a branch channel to the Calumet River, the aggregate to equal the capacity of the main channel, or outlet, below the junction. Two routes for the branch channel are estimated for; the Calumet Northern canal from Summit southeast to the Calumet River at 100th St., and the Sag Valley canal from Sag Station via Blue Island to the Calumet, near the outlet of Lake Calumet. Each route is estimated under two proposals; one in which the 39th St. conduit flows by gravity and the other in which it is operated by pumping works. Under the latter proposition, certain improvements are required in the South Fork in order to maintain navigation.

The three schemes are so entirely tentative at the present time and have so many alternative propositions, that we do not give all the estimates in such detail as those already given for a portion of Scheme No. 1 in our issue of April 4. The summary of the estimate for Scheme No. 2 is as follows, the first column being for the operation of the 39th St. conduit by gravity and the second column for its operation by pumping:

ESTIMATE NO. 1 (with Calumet canal on Northern route).		
Chicago River, moderate impt...	$1,657,510	$1,657,510
South fork	.....	162,030
Main channel.....	179,485	179,485
Calumet Northern canal.....	17,273,611	14,140,312
Calumet harbor.....	811,362	391,465
39th St. conduit (net).....	660,135	5,935,383
Ill. and Mich. canal pump. sta..	480,175	509,125
Calumet flood diversion.....	300,000	300,000
North Branch cut-off.....	500,000	500,000
No. Shore and No. Branch (net).	4,410,582	4,410,582
Total	$26,273,100	$28,185,892
ESTIMATE NO. 2 (with Calumet canal on Sag Valley route).		
Chicago River, moderate impt..	$1,657,510	$1,657,510
South Fork.....	.....	162,030
Main channel	50,000	50,000
Sag Valley canal.....	26,143,274	19,799,234
Calumet harbor	4,083,086	2,280,814
39th St. conduit	2,660,135	7,285,383
Ill. and Mich. canal pump. sta.	418,925	440,175
Calumet flood diversion.....	300,000	300,000
North Branch cut-off..... ...	500,000	500,000
No. Shore and No. Branch (net).	4,410,582	4,410,582
Total	$40,223,512	$36,892,728

SCHEME NO. 3.

This is in general similar to Scheme No. 2, differing therefrom particularly in the treatment and capacity of the Chicago River (which is to be intermediate between the "radical improvement" of No. 1 and the "moderate improvement" of No. 2); and also in the prism and capacity of the branch canal to Calumet Harbor. The flow of water in the river would be such as may be consistent with navigation; a certain additional supply to the main channel would be furnished by the 39th St. conduit by gravity and pumping. The further quantity of water required to develop the full capacity of the main channel below the point of junction with the river would be obtained by a branch canal from Calumet Harbor (either by the Northern or Sag Valley routes). The North Shore treatment is the same as in Schemes No. 1 and No. 2. Two alternatives for this Scheme No. 3 are submitted, both of which are modifications of the "official plan" of the Sanitary District.

This "official plan," as outlined by Mr. Randolph, Chief Engineer of the Sanitary District, contemplates a river 200 ft. wide between dock lines, 16 ft. deep at the dock and 26 ft. at 50 ft. from the dock, maintaining this depth for a central width of 100 ft. The cross section would be 4,700 sq. ft. Bascule bridges are to be built, with 140 ft. clear opening between the pile protection works, the opening to have a depth of 26 ft. for its full width. The cross section in the opening will be 3,640 ft., and the by-passes behind the piers will have an aggregate cross section of 480 sq. ft. Neglecting the by-passes, the net section (deducting 1,000 sq. ft. for the standard vessel) is 2,640 sq. ft. at the bridges, with a capacity of 277,200 cu. ft. per minute at the limiting velocity. Other features of the "official plan" are the Lawrence Ave. conduit (as a means of supplying lake water to the North Branch), the 39th St. conduit (operating to a capacity of 120,000 cu. ft. of lake water per minute), and the Sag Valley canal from Calumet Harbor.

Part 1 of Scheme No. 3, as a modification of the above "official plan," contemplates the development of the full cross section of 4,700 sq. ft. at all points by mounting all new bascule bridges on the dock line, so as to give the full channel opening, and by liberal by-passes at bridge already in place, the aggregate cross section at these bridges (with by-passes) to be 5,000 sq. ft. normal to the course taken by vessels. The capacity under this plan, at the limiting velocity, is about 390,000 cu. ft. per minute. Part 2 contemplates a river 280 ft. wide and 24 ft. deep from the lake to Lake St.; thence 180 ft. wide and 24 ft. deep from Lake St. to 12th St., and thence 280 ft. wide and 22½ ft. deep. The ordinary dock construction would be used for the wider portions and masonry retaining walls in the narrow section. The aggregate estimates of the official plan and the proposed modification are as follows:

Plan.	Operating 39th St. conduit.	Calumet Canal.—Northern route.	Sag route
Official	By gravity.	$27,796,380	$34,534,877
"	By pumping.	30,236,181	34,812,573
Scheme No. 3..	By gravity.	29,028,035	34,764,074
" ..	By pumping.	32,519,621	35,981,424

The Calumet canal (Northern route) would be 122 ft. wide on the bottom, with side slopes of 1 or 2, having a right of way 800 ft. wide. If the 39th St. conduit is operated by pumping, however, the widths of bottom and right of way would be 67 ft. and 660 ft. If built on the Sag Valley route, the dimensions (with the 39th St. conduit operated by gravity and by pumping respectively) would be as follows: 137 ft. and 85 ft. on bottom; side slopes, 3 on 5; harbor, 206 ft. and 200 ft. wide and 18 ft. and 18½ ft. deep. The summary of the estimates for these alternative plans under Scheme No. 3 are as follows:

ESTIMATE NO. 1 (with By-passes at Bascule Bridges).	Gravity.	Pumping
Chicago River.....	$8,528,910	$8,528,910
South fork.....	.....	162,030
Main channel.....	179,485	179,485
Calumet Northern canal.....	12,942,518	10,038,991
Calumet harbor.....	273,000	.....
39th St. conduit (net).....	660,135	6,089,933
Ill. and Mich canal pump. sta.	501,750	526,250
Total	$27,796,380	$30,236,181
Total (with Sag Valley canal instead of Northern route)..	$34,554,877	$34,812,573
ESTIMATE NO. 2 (with Full Channel Width at Bascule Bridges).		
Chicago River.....	$11,074,042	$11,074,042
South fork.....	.....	162,030
Main channel	179,485	521,200
Calumet Northern canal.....	11,651,541	9,458,834
Calumet harbor	243,000	.....
39th St. conduit.....	660,135	6,089,933
Ill. and Mich. canal pump. sta..	509,250	503,000
Calumet flood diversion.....	300,000	300,000
No. Shore and No. Branch (net).	4,410,582	4,410,582
Total	$29,028,035	$32,519,621
Total (with Sag Valley canal instead of Northern route)..	$34,764,074	$35,981,424

SUMMARY OF ESTIMATES.

In conclusion we give a summary of the totals of the estimates for the separate schemes and their modifications or alternatives:

SCHEME NO. 1 (39th St. conduit operated by gravity).	
Radical improvement, river and channel alone.	$22,862,879
Moderate improvem't, river and channel alone..	12,701,755
Radical improvement, complete, total.....	34,600,056
Moderate improvement, complete, total.....	24,438,932

NO. 1.—PART 2: CALUMET SANITARY DISTRICT.

These totals for work complete include the works in estimates of Part 1 and Part 2 (below): the 39th St. conduit, Lawrence Ave. sewer outfall, North Shore canal and Calumet canal (Northern route). The Sag Valley route for this latter canal would reduce either of the above total estimates by $766,406.

Northern route for canal.....	$6,666,460
Sag Valley route for canal.....	3,900,054
No. 1.—Part 3: North Shore Sanitary District..	3,081,760

SCHEME NO. 2.

	39th St. conduit operated—By gravity.	By pumping
Northern route	$26,273,100	$28,185,892
Sag Valley route.....	40,223,512	36,892,728

SCHEME NO. 3.

	39th St. conduit operated—By gravity.	By pumping
Part 1. (Northern route)..	$27,796,380	$30,236,181
" (Sag route).....	34,534,877	34,812,573
Part 2. (Northern route)..	29,028,035	32,519,621
" (Sag route).....	34,764,074	35,981,424

Note.—Schemes No. 2 and No. 3 include the Calumet and North Shore works in Parts 2 and 3 of Scheme No. 1, and also the other works included in the "complete totals" of Scheme No. 1.

CONTINUOUS BANDED WOOD STAVE PIPE.

In our issue of Nov. 8, 1900, we described a new kind of wood pipe, recently put on the market. It was made of staves of Oregon fir, wound spirally with galvanized iron wire under tension. We have since learned that somewhat similar pipe has been made for a number of years past by the California Redwood Pipe Co., of Los Angeles, Cal.

The California pipe is made in sizes ranging from 3 to 10 ins., and to withstand pressures due to heads of 20, 50, 100 or 150 ft. The bands are spaced 2½ to 4½ ins., according to the pressure. They are applied by means of a special machine, the patents for which are held by the company just named. The bands are galvanized steel rods, passed through a bath of hot asphaltum while being wound onto the pipe. The pipe is slightly

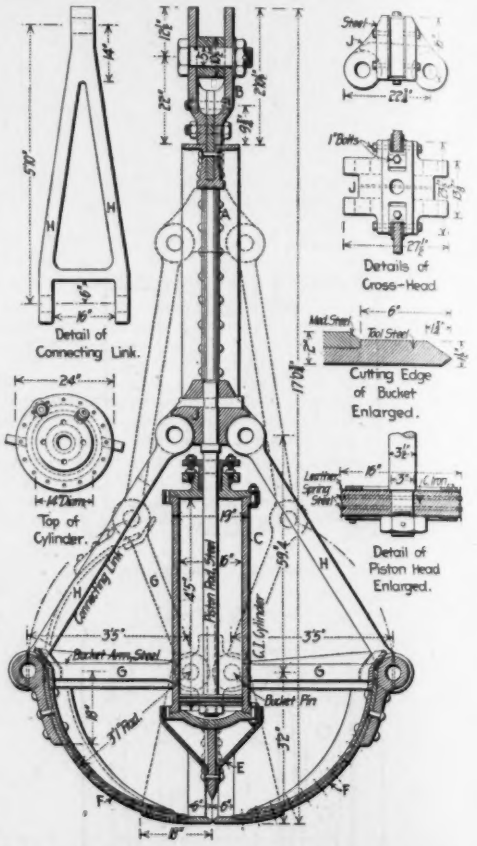


Fig. 1. Vertical Section and Details of Pneumatic Clamshell Dredge Bucket.
Wm. H. Arnold, New York, Inventor.

compressed by using a constantly increasing tension as the winding progresses. This also seats the band slightly into the staves. The pipe is made in lengths of 10 to 20 ft., with ends sawed off at right angles to its axis, and slightly tapered on a turning lathe. These ends fit into cast-iron collars with corresponding tapers, but made ⅛-in. smaller to allow for compresion in driving. The driving is effected by a maul. Special cast-iron fittings are supplied with the pipe.

The East Highland Improvement Co., located at or near Los Angeles, has two lines of this pipe in use. It is 8 ins. in diameter, is under pressures ranging from 0 to 75 ft., and is used to distribute water for irrigating orange trees. It was laid in 1898 and in 1899. Some 4,000 ft. of 3-in. continuous banded pipe was laid in 1899 to supply water under pressure to the La Republica mines, in Southern California. It is placed above ground. As already stated, the pipe has been in use elsewhere since 1885. It is said that nearly six miles of it has been put down by one company.

A PNEUMATIC CLAMSHELL DREDGE BUCKET.

The pneumatic clamshell dredge bucket, which we illustrate herewith, is an innovation on the usual construction of such apparatus which promises to have a wide field of usefulness. As engineers familiar with this type of dredging apparatus know, the ordinary chain-closed clamshell has important objections; the bucket can be closed only after it has come to rest on the bottom, and the pull of the closing chains reduces the effective digging weight of the bucket owing to their lifting action. To avoid these objections several attempts have been made to devise buckets closing by the action of liquid pressure in a cylinder, but so far none of these devices has gained much favor. The bucket illustrated here is one of the latest of these devices, and its very successful operation in the trial installation promises, as stated above, to reverse the poor success met with by previous buckets of the sort. In it the opening and closing of the bucket is performed by air pressure operating through a cylinder and piston, the action being wholly independent of the hoisting chains and of the position of the bucket.

The construction of the bucket is, perhaps, best seen from the sectional drawing, Fig. 1. The central element of the bucket is the frame, A, which terminates at the top in a fork, B, and at the bottom in a cylinder, C. Between the arms of the fork is pivoted a compensating bar, D, to the ends of which are attached the hoisting chains, and at the bottom of the cylinder is a wedge-shaped cylinder-head guard, E. The compensating bar serves to keep the bucket vertical in descending, while the cylinder-head guard serves as a means for anchoring the bucket or for holding it while filling in a fixed position in the material to be removed. The shells, F F, of the bucket are hinged to the frame by four bucket arms, G, and are also hinged to the crosshead, J, by the triangular connecting links, H. This crosshead is keyed to the top of the piston rod and slides between interior guides on the two members of the frame. Minor details of the construction are clearly shown by the drawings.

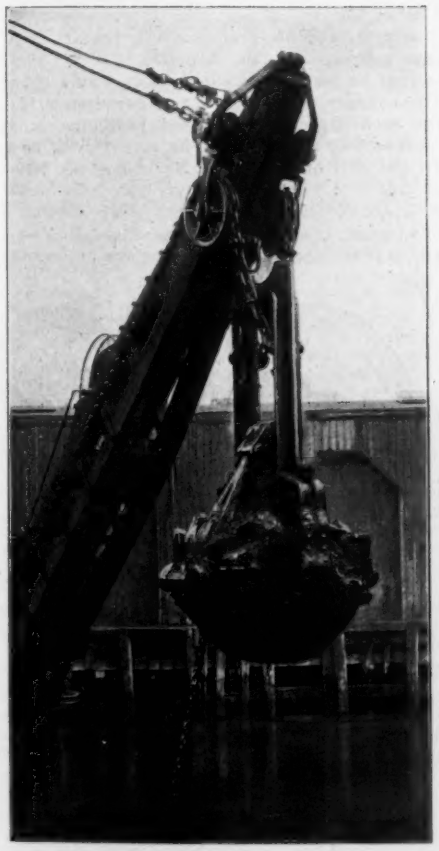


Fig. 2. View of Pneumatic Clamshell Dredge Bucket Closed With Load.

In operation, the jaws or shells of the bucket are both opened and closed by the positive action of the air pressure upon the bottom or top of the piston. The air is conveyed to the cylinder from the receiver on the dredge through a double barreled or Siamese hose arranged as described later. The full lines, Fig. 1, show the positions of the crosshead, connecting links, bucket arms and jaws when the bucket is closed, and the broken lines show these parts, for one side, when the bucket is open. It will be observed from the drawing that the opening and closing mechanism is wholly independent of the devices by which the bucket is hoisted and lowered, so that it may be opened or closed at any point in its vertical travel. Furthermore, it will be seen that when the bucket rests on the bottom its whole weight is effective for digging, the hoisting chains remaining slack until the jaws are closed.

Turning now to Figs. 2 and 3, showing the trial installation of the bucket, it may be noted first of all that while the drawings of Fig. 1 show the jaws made up of riveted pressed steel shapes, the bucket as actually installed has cast steel jaws. At the time the bucket was built this was a decided innovation, but since then cast steel has been used in several clamshells which like the first appear to have been highly successful. Fig. 2 shows the bucket loaded and closed, ready to be swung over the scow and dumped, and Fig. 3 is a view showing it open with somewhat more of the dredge boat in sight. As will be observed, the only modifications required on the portion of the dredge in sight is the hose reel on the boom. Inside, of course, there are the unusual installations of an air compressor and receiver.

The problem of handling the hose during operation was a somewhat critical one. It was necessary, of course, that the hose should freely follow the bucket in its descent and as freely and quickly be gotten out of the way in the ascent of the bucket. It was highly desirable also that these operations should be automatic. The solution of the problem which was finally worked out is exceedingly simple. A vertical hose reel with a hollow shaft or axle is carried on bearings on the top member of the boom. From the receiver two lines of iron pipe pass up the boom and terminate in the ends of the hollow shaft. The double hose has connections tapped into the shaft to admit the air to it. In operation the hose is unwound from the reel by direct pull when the dipper is descending. This action, of course, rotates the reel and this rotation winds up a cable attached to a counterweight which slides up and down the boom on an interior track. When the bucket begins to ascend and releases the tension on the hose the counterweight acts by gravity to unwind the counterweight cord which rotates the reel in the reverse direction and winds the hose onto it as fast as it comes up out of the water. As will be seen, both the unwinding and rewinding actions are wholly automatic and require no particular care on the part of the operator.

The bucket illustrated by Figs. 2 and 3 is installed on the dredge "Champion," belonging to The W. H. Beard Dredging Co., 11 William St., New York. At the time the photographs were taken, this dredge was at work digging mud from one of the slips of the Brooklyn Warehouse & Terminal Co., of Brooklyn, N. Y. As previously stated, a double or Siamese hose was used, one barrel of which supplied air to the bottom of the piston and the other to the top of the piston. A pressure of 100 lbs. per sq. in. was worked. The admission of the air to the cylinder and its exhaust were controlled by a three-way cock on each of the two lines of pipe leading to the hose, these cocks being placed in the operator's cabin close to the hand of the dredge operator. At the time the dredge was visited by a member of the staff of this journal, the work of filling a scow was just being completed. The bucket operated quickly and smoothly so far as could be observed and required even less care on the part of the operator than the ordinary chain-closed bucket. Fig. 2 is a fair illustration of the bucket loads which were being regularly removed. The soft material, of course, favored the bucket, particularly since it was of small size, designed for hard digging.

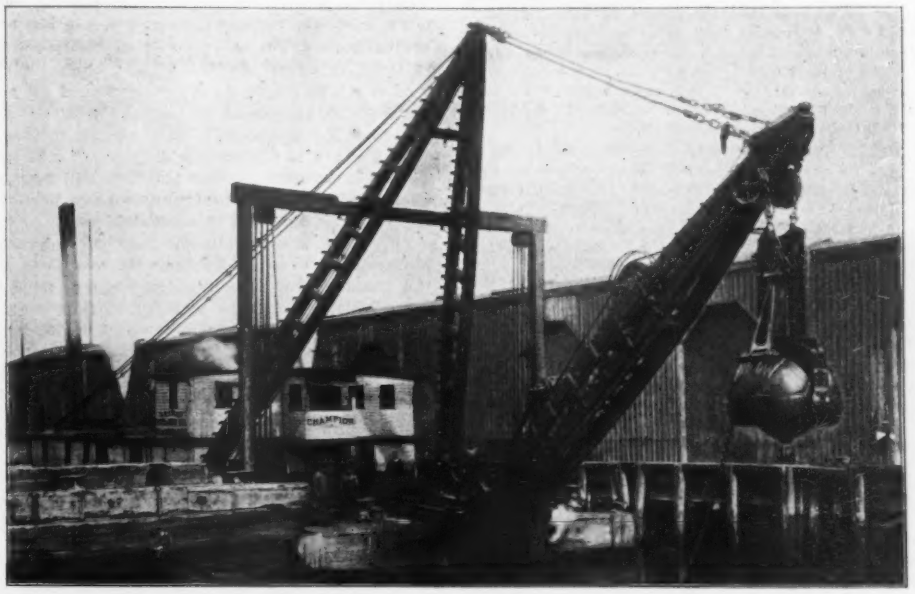


FIG. 3. VIEW OF DREDGE "CHAMPION" EQUIPPED WITH PNEUMATIC CLAMSHELL BUCKET.

Summarized briefly, the main dimensions of the bucket are: Capacity, 3 cu. yds.; extreme height, 15 ft.; extreme width, 76 ins.; diameter of cylinder, 16 ins.; area of piston, 200 sq. ins.; length of stroke, 4 ft.; working pressure of air, 100 lbs. per sq. in.; total pressure on piston, 20,000 lbs.; total weight of reciprocating parts, 9,000 lbs.; total closing force on material, 29,000 lbs.; actual weight of bucket, 24,000 lbs. This bucket was designed for hard digging.

For soft material a larger bucket would be employed and for handling blasted rock the bucket shells would be replaced by grapples.

The advantages claimed for this form of clamshell over chain-closing buckets are: Closing and opening independent of use of frictions; bucket can be lowered into scow well and dumped on the doors without dropping the load; a gain of about 10 ft. in width of cut is made owing to the fact that the chain-closed bucket will fall off in opening; the entire weight of the bucket is on the bottom while closing, and finally the ability to close the bucket at a given depth enables the dressing off of the bottom of the cut at the required depth without over excavation.

The bucket illustrated was designed and has been patented by Mr. W. H. Arnold, engineer and superintendent for The W. H. Beard Dredging Co., of 11 William St., New York. We are indebted to Mr. Arnold for the information from which this description has been prepared.

NOTES ON FOUNDRY PRACTICE.*

By Edward B. Gilmour.†

The founder of to-day is able to intelligently mix his iron to suit various requirements, and not trust to chance, as was formerly the case. Foundry management is becoming a science and, therefore, he who directs the foundry must learn to understand the science of foundry practice or he will, in the near future, be seriously handicapped. Foundry irons are grey or mottled, and are divided into grades, and numbered according to the quality as shown by the fracture; but with the advancement which is going on at the present time these numbers are gradually being abandoned and iron is ordered by chemical analysis to better suit requirements.

CARBON.—The various percentages of carbon in iron determine its quality as cast iron, wrought iron or steel. It exists in combination with iron in two distinct forms, viz., graphitic and combined carbon. When it is in the graphitic state the cast iron is soft and easily fusible. This is the element which most of all determines the strength of the metal. Graphitic carbon is always present in iron in a mechanical form, and is easily distinguished from the other form, which is in the combined state. This combined carbon is known to exist in several conditions, but there has not been any good method for separating them devised as yet.

SILICON.—By a judicious use of this element the founder may change the combined carbon to the graphitic, or vice versa, as he requires. When carbon has all become graphitic the further addition of silicon has a hardening effect. Silicon is not a softener of iron nor is it a lessener of shrinkage, but through its action on carbon and only for a given range does it produce these effects. The loss of silicon in remelting in the cupola is not heavy, and cast iron which contains just enough silicon to prevent hardness and give a solid casting is the best composition to use. If strength be more important than softness we can leave the greatest amount safely possible of the carbon in the combined state, without, however, causing the iron to be too brittle.

Silicon introduced into carbide of iron will throw out graphite; but if manganese carbides or titanium carbides are present, silicon will not be as effective. Silicon combines very readily with iron, but for foundry purposes from 1 to 3% is the range, according to the class of work in hand, the thicker the casting the less of it being required.

MANGANESE.—Manganese alloys with iron to an unlimited extent. Beyond hardening it has no very detrimental effect upon the metal, and in many cases it is even beneficial by making iron readily susceptible to chill and close in the grain, and it assists in eliminating blowholes. Care must be taken in using this element, as it increases shrinkage, and if the design of the work is not in accordange with the laws of crystallization it will cause the casting to crack very readily. One good feature of this element is that it removes sulphur to a great extent and thus prevents red-shortness. The percentage of manganese is reduced very heavily in remelting in the cupola, so that about 0.8% of it in the original pig for heavy castings would be about right.

PHOSPHORUS.—Phosphorus weakens iron, particularly when it reaches 4 or 5%. About 1% is very beneficial in stove irons. It reduces shrinkage. High phosphorus irons should be poured at a lower temperature as it renders the metal very fluid, everything else being normal. Phosphorus causes cold-shortness or brittleness when cold.

SULPHUR.—This non-metallic element combines with iron very readily at low temperatures. It is undoubtedly the most injurious element that we have to contend with in foundry mixtures, and causes iron to be weak. It also makes iron white and hard. Sulphur is not readily removed from the iron in remelting, but it is found that the temperature of the cupola has an effect on the percentage of sulphur in the iron. At high temperatures the sulphur will tend to go into the slag, as there is not so great an affinity between iron and sulphur under these conditions. If at any time you have to stop the blast or reduce the blast pressure in your cupola while melting, it will reduce the temperature; and, consequently, the sulphur of the coke will unite with the iron more readily. When this element is present in iron it increases the combined carbon and affects the crystallization somewhat. In buying iron you sometimes get iron high in silicon, high in sulphur, high in combined carbon and low in total carbon, the iron showing a very good fracture in the pig, but if cast in a chill mold a sulphur chill, independent of the silicon, will quickly show up, indicating that this iron is not suited for very light castings or castings which are to be machined. Again, if you put into the cupola iron which is comparatively free from sulphur and do not melt it very hot it will absorb the sulphur from the fuel and your castings will be high in sulphur. High sulphur castings are filled with blow-holes and not easily machined, and when the molten iron comes in contact with damp sand a chill and excessive shrinkage will result. If you know that your iron is all right before melting and have trouble with your castings, increase the temperature in your cupola.

*From the "Journal of the American Foundrymen's Association," for May.
†Milwaukee, Wis.

TELEPHONE TUNNELS IN CHICAGO.

An interesting piece of work which is in progress at Chicago, but of which little is known, is the construction of a network of tunnels or subways for a new telephone system which is being established by the Illinois Telephone & Telegraph Co. The map, Fig. 1, shows the city portion of the work, with five lines of tunnels running north and south, and eight lines east and west. Beyond the limits of this map the Franklin St. tunnel will extend north to North Ave., a distance of 1.6 miles; the Monroe St. tunnel will extend west to Western Ave., 2.5 miles; and the State St. tunnel will extend south to 65th St., a distance of 8.33 miles. The entire system, as now planned, will aggregate about 12 miles, and the tunnels have been completed for a distance of several blocks.

The main shaft is in the rear of a house on Madison St., between La Salle St. and Fifth Ave., the basement of the building being used for power plant, concrete mixing, storing material, etc. The shaft, 7 ft. diameter and 35 ft. deep to the tunnel floor, is at the extreme end of the lot, so that the excavated material can be dumped directly into wagons standing in the alley behind

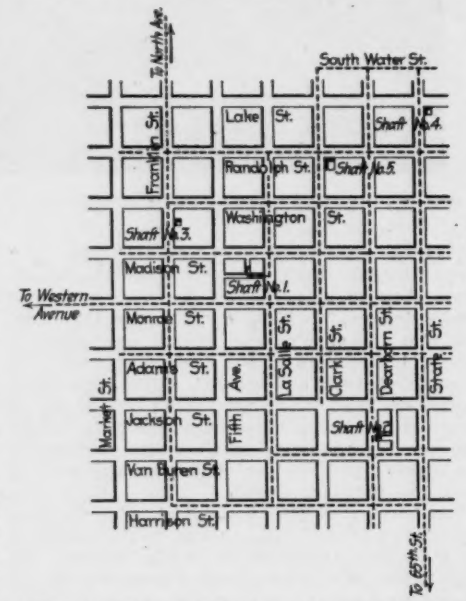


Fig. 1. Plan of Telephone Tunnel System in Chicago.

the building. Stone, sand, cement, etc., are unloaded from wagons in Madison St., and sent down a chute in the sidewalk to a horizontal belt conveyor in the basement of the building, by which the materials are carried to suitable bins. Tracks of 14 ins. gage are also laid in the basement for the mine cars carrying concrete, etc., from the mixer to the shaft, and thence to the tunnel headings. The belt conveyor is driven by an electric motor of 10 HP., and the other plant includes a Drake concrete mixer operated by a horizontal steam engine, and an air compressor having a capacity of 400 cu. ft. per minute. Of the other four shafts shown on the plan, three are in the basements of buildings, and have practically similar equipment to that of the one above described. Shaft No. 2, however, is sunk on the curb line of Dearborn St., and is surrounded by a head-house, 6 × 6 ft., about 25 ft. high, of timber construction with corrugated iron sheathing. The cage is hoisted about 10 or 12 ft. above the street level, and the cars are run out on a platform over the sidewalk, from which the material is dumped into wagons. Other shafts will be sunk as required.

The tunnels are almost entirely in stiff blue clay, the men using spades and hoop-shaped drag knives for excavating. There is very little moisture, but pockets of quicksand and gas are occasionally encountered. The centers are 3 ft apart, with lagging on the outside, and the work is done in 16-ft. lengths. The tunnels are 8 ft. high inside, with a maximum width of 6 ft. They have curved walls and an invert, as shown in the section, Fig. 2. They are lined with concrete 10 ins. thick, composed of 1 part Portland cement, 3 parts lake torpedo sand and 5 parts clean crushed limest... This is thrown in from the front of the head... and rammed back against the completed w... The surface is finished off with cement pla... All work is carried on under an air pressure o... lbs., the air lock being 23 ft. long, with end d... 24 × 36 ins. No signs of settlement have been observed, though the tunnels pass under streets between very tall and heavy buildings. The t... nels are lighted by 110-volt incandescent la... 30 ft. apart, attached to blocks fastened to ... crown of the arch. Electric lights are also ... in the headings, to prevent explosions due t... pockets of gas. The temperature of the tunn... is about 75° F.

The work is done by three shifts of men work... eight hours each. From 5 p. m. to 1 a. m. the mucking gang of 7 men at the heading does the excavation, the material being hauled to the shafts on mine cars on a track of 14 ins. gage (with turntables at the various intersections). From 1 a. m. to 9 a. m. the trimming gang of 7 men trims the excavation to proper section and sets the centering and forms. From 9 a. m. to 5 p. m. the concrete gang carries on the building of the lining. The excavated material is hauled away only between the hours of 7 p. m. and 5 a. m., when wagons are driven up to the shaft houses (generally in the alleys), the cars being run on dumping tracks on the second floor level. Material which cannot be removed during these hours is kept in the cars, which are run on storage tracks in the basement or upper floors.

At intersections of the main tunnels, the corners are rounded off and the roof is supported by steel I-beams and concrete jack arches. At alleys where surface connections are to be made, lateral drifts 3 ft. diameter are driven from the main tunnels, the top of the drift being level with that of the tunnel, as shown in Fig. 2. The wires will be carried by iron horseshoe frames.

The Illinois Telephone & Telegraph Co. was granted a franchise in 1899, and its system will be automatic, dispensing with switchboard attendants at the central station. This will give a secret system with practically a private line to each instrument. It is proposed to wire buildings so that an instrument can be placed in any room. The charges will be on the meter system, 5 cts. for each call being charged until the amount reaches $85, after which the service will be free for the rest of the year. Mr. Albert G. Wheeler is President of the company. The work is being done by the Illinois Telephone Construction Co., of Chicago, the General Manager and Engineer of which is Mr. George W. Jackson, the builder of the

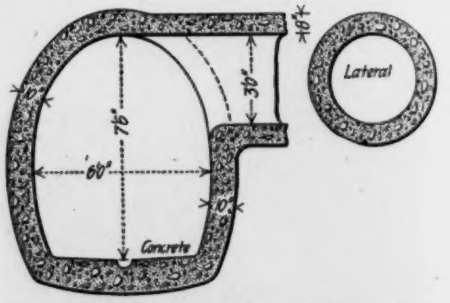


Fig. 2. Cross-Section of Main Telephone Tunnel and Lateral.

Strickler tunnel under Pike's Peak for the water supply of Colorado Springs, Colo. Progress records are kept on blank forms similar to that shown in Fig. 1, 8½ × 11 ins. in size, upon which the headings are marked as the tunnels progress.

A GERMAN LIFE-SAVING APPARATUS, lately patented, is equipped with a long tin cylinder carrying in 12 compartments carbide of calcium. When this buoy is thrown into the sea water coming in contact with the carbide generates acetylene gas, and an electric apparatus produces a 150-c. p. light, which will burn for 3 or 4 hours. Each compartment is connected with the burner by a pipe, and as the volume of gas in one compartment decreases a valve is automatically opened and water enters the next compartment. The whole apparatus weighs only 33 lbs., and the buoy is globular in form and carries from two to four life belts.

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